SURVEYS of NATURE,

HISTORICAL, MORAL,

and

ENTERTAINING,

exhibiting the

PRINCIPLES of NATURAL SCIENCE

in various Branches,

by

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ADDENDA

TO THE

FIRST VOLUME.

EXPLANATION OF THE FRONTISPIECE.

THIS repreſents NATURE, ſurrounded by the four Elements; on *Earth* ſhe ſtands, *Water* appears guſhing from a ſpring, *Fire* from a volcano at a diſtance, *Air* is hinted at by the rainbow. The feet of the figure, we ſee, as well underſtanding her ſtability; but the major part of her is enveloped in clouds, as beyond our inveſtigation. The many rows of breaſts indicate her perpetual care, ſupport, and nouriſhment of her offſpring. She turns in grateful admiration to that celeſtial light which viſits her, and by which ſhe is at once illuminated and cheriſhed.

Page 42. The mountains in the moon were formerly thought to be three times as high as any we have on earth; but Mr. HERSCHELL has lately been of a contrary opinion, and thinks them below the terreſtial.

Page 54. It ſhould have been obſerved in explaining this plate, that the moon's nodes (M. 1.) are retrograde, and will not return to this point again till nearly nineteen years are expired; but will be continually changing place throughout the ſigns, at the rate of above nineteen degrees yearly, meeting the ſun every year nineteen days ſooner than the year before.

Page 56. The limits of ſolar eclipſes extend to ſeventeen degrees from the moon's nodes: if within that ſpace, the ſun may be eclipſed; without that ſpace, the moon is either too high or too low for any part of her ſhadow to fall on the earth, as at fig. 3. When the ſun is more than twelve degrees from the node, the moon is generally too high or too low to go through any part of the earth's ſhadow, as fig. 7.

Page 61. The computation of the planetary diſtances aſſumed in this page is much below the truth; but, as it was eſteemed ſufficient for general purpoſes, was not changed. More accurate eſtimations conſider the mean diſtance of

MERCURY to be	36,841,500 miles
VENUS - -	68,891,500
THE EARTH	95,173,000
MARS - -	145,014,000
JUPITER -	494,991,000
SATURN -	907,956,000
GEORGIAN	1,900,000,000

It is to be obſerved, that an error of a ſingle ſecond in taking obſervations of the ſun's parallax, cauſes an error of ſeven millions of miles in diſtance; and perhaps, after all, we may beſt be contented with round numbers, preciſion being ſcarce expectable. The diameters of the planets are to be eſtimated at a proportional increaſe, as alſo the bulk of the ſun.

Page 66. MERCURY is ſo ſeldom happily placed for obſervation, that aſtronomers differ in opinion of his ſize, ſome making him 2600 miles in diameter at leaſt.

Page 67. The EARTH moves in her orbit, at the rate of 68,000 miles per hour: 1,130 per minute. The circumference of her orbit is nearly 600,000,000 miles.

MARS circulates in 686 days, 23 hours.

JUPITER circulates in 11 years, 314 days, 12 hours.

Page 68. SATURN circulates in 29 years, 167 days, 5 hours.

An additional moon, interior to the others, has very lately been diſcovered by Mr. HERSCHELL, circulating in 32 hours, 48 minutes.

The GEORGIAN is diſtant from the ſun nineteen times the diſtance of the earth, and nearly one-tenth.

The inclination of his orbit is only 46′. 26″.

His period 30,456 days, 1 hour, 40 min. i. e. 83 years, 161 days.

His diameter is four times that of the earth, and nearly one-third.

His bulk 80 times and a half that of the earth.

Of his ſatellites,

The period of the firſt is 8 days, 17 hours, 1 minute.

Diſtance from the planet 33″.

Period of the ſecond 13 days, 11 hours.

Diſtance from the planet 44″. 23‴.

Its orbit inclined to the ecliptic 90°.

Page 71. The velocity of the planets in their orbits is ſo conſequential, that Mr. FERGUSON has calculated in what time they would fall to the ſun, ſuppoſing that velocity deſtroyed.

Mercury in 15 days, 13 hours.
Venus in 39 days, 17 hours.
Earth in 64 days, 10 hours.
Mars in 121 days.
Jupiter in 290 days.
Saturn in 767 days.

The Moon would fall to the Earth in 4 days, 21 hours.

Page 72. Almoſt every year ſeveral new COMETS are diſcovered; they are moſtly very ſmall; we ſeem to be juſtified in ſuppoſing an hundred may belong to our ſyſtem.

Page 130. Mr. HERSCHELL has given a very numerous catalogue of double and triple ſtars: by calculating the whole expanſe of the heavens, according to what he has actually ſeen by his great teleſcope, he eſtimates the ſtars at 75 millions—how many more may there be that no teleſcope ever ſhall diſcover!

Page 140. During a fortnight in winter, and that its luminous period, the moon never ſets at the poles: this is to be added to balance the account. Winter is a time of rejoicing in the North.

Page 177. Add at bottom—KEPLER computes that the ſun was 5° below the horizon when they ſaw it; and refraction nine times greater than with us.

Page 190. The air is very rarely denſe enough at two miles high to ſupport clouds.

Page 214. The increaſe of weight in freſh burnt lime, when expoſed to the air, is alſo a proof of the weight of the air.

Page

Page 221. "Air is thought to *cool* the blood." Dr. CRAWFORD has lately revived and ſupported a theory which conſiders air as the grand medium of heating the blood; and this ſeems very conſiſtent with warm-blooded animals reſiding principally in air (whales, &c. are exceptions), and cold-blooded animals being either amphibious or reſident totally in water, where they procure air in a peculiar manner, probably in ſmall quantities, and to that they may be beholden for what little warmth they poſſeſs.

Page 225. *Light inflammable air* is procurable from a great variety of ſubſtances: the ſpirits of vitriol are not neceſſary; it burns with a pale but lively green colour; is not kept pure without difficulty.

Page 226. There is nothing more perplexing than the variety of names in chemiſtry for the ſame thing: *fixed air* is alſo called *mephitic gas* and *aerial acid*; that it has an acid quality is very probable.

Page 252. The ocean is *red* below, though *green*, &c. above.

Page 295. Fire acts remarkably *upwards*, and will ſcarce find its way, but by creeping, downwards; whether this is a property belonging to itſelf, or it is ſo impelled by the rarefied air which accompanies and excites it, may be queſtioned.

Page 313. Opake bodies not only repel, but they ſtifle and abſorb the rays of light which fall on them, beating and re-turning them ſo often, in their pores, that they loſe their original direction and courſe.

Page 323. Does the admixture of light in the ſolar rays indicate different origins for the luminous particles, as if there were any diſtinctions on the ſun's body—ſuch as land and water with us?

Page 329. Fleſh in barrels will not take ſalt if expoſed to the rays of the moon.

SECOND SERIES OF LECTURES.

Page 96. The viper mentioned in this paragraph lived a fortnight in this condition.

Page 98. The food of the little polypi does *not* paſs into the parent's body.—See the hiſtory of this creature in its place.

Page 203. In ſome animals is but one ſmall bone; in others are two; in others three; their uſe and action conſtantly the ſame. There is great variety reſpecting the maſtoide cells: in ſome they are large; in others ſmall; in the cat kind only one large cell. Some aſſert ſerpents have not theſe cells. The ear is *ſituated* alike in all; but *directed*, in lions, &c. toward their prey; in hares, foxes, &c. toward their purſuers.

EXPLANA-

EXPLANATIONS OF THE FRONTISPIECES.

SPRING

Is repreſented engaged in diſplaying a garland compoſed of thoſe productions which are peculiar to herſelf, flowers: the budding trees renew their verdure, and the animal creation experiences its vegetating power.

SUMMER,

Crowned with leaves and loaded with a ſheaf of early corn, ſeems juſt to have employed her ſickle in cutting it down; the heats of the ſeaſon are indicated by the repoſing mowers, and abundant renovating not without thorns, appears around.

AUTUMN

Boaſts the riches of Pomona, and holds a cornucopia filled with fruits of various flavour: the luxuriant vine is her peculiar donation; ſhe is therefore crowned with vine-leaves, and holds in her hand a bunch of grapes; the proceſs of the vintage is hinted by the boys in the back ground, and its joyful concluſion by the thyrſus, the tabor, and the flagon, in front.

Winter

Is the old age of the year, and requires artificial warmth to compenſate for the abſence of natural; gloomy and bare of itſelf, yet, by the opportunity it affords for the chaſe, and its game, offering abundant means of ſocial feſtivity.

Air

Is naturally ſeated on clouds; her hair and drapery agitated by the wind; ſurrounded by inhabitants of the air, birds; and eſpecially careſſing a peacock, which bird was anciently ſacred to Juno, the goddeſs of the air.

Water,

Surrounded by her attributes, or principles, needs little explanation: deſcending from the clouds in rain, which furniſhes rivers, ſtreaming from her vaſe, ſurrounded by water plants; in the ocean yielding many riches to incite capture, ſignified by the boy hauling his nets; and many curious productions alſo, ſignified by the marine ſhells in front.

Earth.

On her head the ſymbol of civic towers, as the reſidence of man; in her hand a cornucopia full of her rich gifts; around her variety of animals that reſide on her dominions, of trees and flowers that derive their ſupport from her. She is ſeated on a globe, ſuch being her form as a planet.

Fire.

We are certainly obliged to the ſun for heat, if not for fire; that luminary therefore appears with propriety in this compoſition: but as we are capable of producing fire from earthly materials, and of maintaining it, ſuch is the employment and indication of this figure.

Feeling,

Not confined to man, is enjoyed by all animals, eſpecially by ſuch (as monkeys) that have hands; the ſnail alſo ſeems very ſenſible, and gives manifeſt tokens of it by the motions of its horns: among plants, the ſenſitive is the moſt remarkable in this reſpect, for, when touched, it ſhuts and contracts its leaves; this the figure holds in her hands, and is ſhewing its properties; ſome leaves being open, others cloſed.

Seeing

Reſpects objects both near and diſtant: the young man looking at himſelf in a mirror exhibits the firſt; the boy looking through the teleſcope expreſſes the ſecond: the ſoaring eagle is the keeneſt of ſight among birds, and therefore probably of all creatures; and the brilliant rainbow is among the moſt beautiful objects offered to delight this ſenſe.

Hearing,

As related to muſic, is expreſſed by the figure playing on the guitar, to whoſe harmony the boys ſeem attentively liſtening. This

ſenſe as beſtowed on animals, is hinted by the fawns and the hare; and as repeated in echoes, is hinted by the ſurrounding ſcenery of rocks, &c.

SMELLING

Is moſt powerful at early dawn; then the fragrance of vegetation is moſt ſenſible, and then the dog, who poſſeſſes this ſenſe in perfection, moſt readily tracks his game; flowers and perfumes regale this ſenſe, which is imported by the flowers in the hand, the cenſer below, the pot of unguent, and the crown of ſweet ſmelling plants.

TASTING

Ariſes from the vegetable or animal kingdom: to the firſt refer the baſket of fruits, and the vines on the diſtant hill; to the latter the falcon and domeſtic cattle; the horſe's bit lying on the ground hints at moderation, in no ſenſe more neceſſary than in this.

END OF THE FIRST VOLUME.

ERRATA IN THE FIRST VOLUME.

Page 12, line 7, *for* league after league deſcending; without, *read* ſteep after ſteep, deſcending without.—Line 10, *for* huzza, *read* ſhout.

Page 21, line 12, *for* oils we know are ſo, *read* certain chymical oils we know are ſo——the aſſertion as it ſtands is falſe; perhaps the idea is yet more familiarly exemplified in milk or cream ſinking in a diſh of tea.

Page 54, line 8, in ſome copies, *for* orbits, *read* orbit.

Page 96, line 17, *read*, Whoſe ſober wiſhes never learn to ſtray.

Page 107, line 13, *for* fig. 6 may be conſidered, *read* fig. C. may be conſidered.

Same page, line 19, *for* fig. 1, being void, *read* fig. I, being void.

Page 137, and elſewhere, *for* verticity, *read* verticality.

Page 161, line 3 from the bottom; *for* on this circumſtance depends, *read* partly depends.

Page 164, line 21, *for* what they appear, *read* where they appear—*for* allowances, *read* allowance.

Page 173, *for* pea-bloſſom, damp of mines, *read* pea-bloſſom-damp, of mines.

Page 214, line 16, *for* than water, *read* than that of water.

Page 218, line 14, by a ſcale, *add* of feelings.

Page 242, line 3 from bottom, *for* predominant, *read* moſt predominant—*and for* leaſt water, *read* leaſt of water.

Page 274, line 14, *for* blown from its ſurface, *read* from the ſurface of its box.

Page 278, line 15, *for* boaſt of, *read* boaſt.

Page 303, line 5 from bottom, *for* effects, *read* principles.

Page 315, line 21, *for* from the ſun, *read* originally from the ſun.

SECOND SET OF LECTURES.

Page 59, line 8, *for* contraſt, *read* contravent.

Page 60, line laſt but one, *dele* or inclination.

Page 61, line 10, *for* creatures ſeem, *read* creatures are.

Page 63, line 3, *for* ſeparated, *read* ſeparating.

Page 76, line 3, *for* ten times an hundred, *read* ten times ten hundred.

Page 80, line 11, *for* where the tree was, *read* in circumſtances ſimilar to thoſe of the tree.

Page 85, line 15, *for* wind around a ſturdy tree, *read* wind around a ſtately tree.

Page 91, line 16, *for* muſcles, *read* muſſels.

Page 94, line 20, *for* having its parts appropriate to their different, *read* having parts appropriate to different——

Page 103, line 1, *for* approached toward, *read* advanced in.

Page 124, line 4, *for* a part of it, *read* part of its contents.

Page 192, line 9, *for* called *nictitans*, read called *membrana nictitans*

PREFACE.

IT has long been the opinion of the Author of the following Diſcourſes, that to treat ſcientific ſubjects in an eaſy and familiar manner, is to render very eſſential ſervice to thoſe perſons in general who are deſirous of acquiring information without deeply ſtudying ſuch ſubjects; and eſpecially to the younger part of the community, to whom entertainment is ever welcome. Upon this principle the Author conducted the LECTURES in the ARTIST's REPOSITORY and DRAWING MAGAZINE, and the ſatisfaction of the Public with that performance has amply juſtified the idea; in fact, it is to the favourable reception of that work the preſent owes its appearance: It is preſumed, it will not be found leſs worthy of favour, or leſs agreeable in its nature. It would give its Author great pain to think that public encouragement had rendered him careleſs, or that his ſucceeding labours were no improvement on his former; on the contrary, as the *principles* now adopted are the ſame as before, and the *ſubjects* more general and intereſting, he flatters himſelf, the *execution* will be found proportionally ſuperior and valuable.

It is his deſire that deep or abſtruſe diſquiſitions may not be expected, nor any mathematical calculations, or ſolu-

tions; nothing but what is free, general, and of eaſy conception to the reader; though to render it ſo, has often been more difficult to the Author than if he had written it in a technical manner.

He begs leave to conclude, by repeating his former ſentiments, (only changing the name of the performance) from the ARTIST'S REPOSITORY.

"Upon the whole, it is hoped the Public will receive from the SURVEYS of NATURE both inſtruction and entertainment, united in a compendious ſyſtem: if, in its progreſs, profeſſed Artiſts ſhould ſometimes think it paſſes too ſlightly over objects uſually ſuppoſed of conſequence, they are requeſted to recollect the perſons to whom it is chiefly addreſſed; if, on the other hand, it ſhould ſometimes be thought too learned, the public will excuſe this error (if ſuch it be) in a performance, whoſe Editor is deſirous of imparting knowledge and information, which will certainly prove of advantage to his readers, and perhaps ultimately to philoſophy itſelf."

*** The courſe intended by the Author, and which ſeems moſt regular for ſuch a work, is, to conſider (i.) the *celeſtial phenomena*, *Sun*, *Moon*, &c. whoſe influences have great effect on (ii.) *terreſtrial phenomena*, Light, Air, Clouds, Rainbow, &c. then to ſurvey (iii.) *the Earth*, then (iv.) its inhabitants, *Man*, *Animals*, *Reptiles*, *Inſects*, &c. down to (v.) the minuteſt diſcoveries of the microſcope.

INTRODUCTORY LECTURE.

THE moſt noble and valuable prerogative of mankind above ſurrounding creatures, is, that reaſoning faculty whereby we inveſtigate the properties, the actions, and the relations of natural objects; whereby we ſurvey the works of wiſdom, and diſtinguiſh their importance and deſign. To what purpoſe has the Great Author of Nature diverſified the operations of his hand; ſometimes proportioning them on a ſcale of immenſe magnitude, ſometimes animating the moſt diminutive atoms; to ſome beings imparting aſtoniſhing faculties, beſtowing on others bare exiſtence? To what purpoſe is this variety?—That it might excite our attention, gratitude, veneration, and love.

To ſurvey the wonders of Nature without admiration, without thankfulneſs, without piety, implies frigidity of ſpirit, or ignorance of mind, little leſs than brutal: Such a man (if ſuch a man there be) is unworthy the name he bears, and rather ſhould be degraded beneath humanity; for humanity is diſtinguiſhed by faculties more excellent than any we diſcern in the creation around us.

Nothing is more conducive to our happineſs and welfare than a juſt ſenſe of our native dignity; but this is not to be obtained without reflection, without adverting to the qualities of our fellow creatures, who ſeem in ſo many reſpects beneath us, or without attention to the more magnificent operations of Nature, where our ideas are loſt in wonder. When we regard only our inferiors, we ſeem almoſt divinities; when we inveſtigate the ſtupendous diſplays of power diſcovered by obſervation, we ſeem leſs than nothing, and vanity.

The progreſs of thoſe LECTURES, to which this is introductory, will occaſionally requeſt your attention, LADIES and GENTLEMEN, to both theſe extremes. The prodigiouſly extenſive magnitude of ſome ſubjects, their ſurpriſing properties, their aſtoniſhing effects, ſurpaſs the powers of language:—let me, on ſuch inſtances, beſpeak your candid indulgence; where genius, and learning, and philoſophy themſelves fail, let a humble follower of them expect ſucceſs with diffidence. Nor is it leſs difficult to do juſtice to other articles whoſe extreme minuteneſs conceals many of their peculiar wonders; but, if an earneſt deſire for your information and entertainment, may be thought, in any degree to counterbalance theſe impediments, I flatter myſelf we ſhall have no juſt reaſon to regret the time ſpent in theſe diſcourſes.

Is it neceſſary I ſhould enlarge on the benefits of acquaintance with natural knowledge, or point out the advantages

advantages derived from inſpection of natural objects? Shall I tell you, this diſtinguiſhes polite life from ſavage barbarity; that, to be ignorant, is perpetual childhood; that the faculties of the mind are not only matured, but enlarged by reflection; that to remain below thoſe attainments, to which we are competent, is injuſtice to our talents, and to our enjoyments? or ſhall I expatiate on the entertainment, the delight of knowledge, and the pleaſures ariſing from elegant ſtudy? You will readily own, that there is in the human mind a conſtant thirſt after novelty, an ardent deſire of further acquiſitions; never ſatisfied with its actual poſſeſſions, never contented with its preſent ſtores, it ruſhes after propoſed benefits, and explores with unwearied aſſiduity every quarter in which it ſuſpects new or unnoticed information.

In fact, this diſpoſition of the mind is notorious; nor is it unaccompanied by hazard and riſk: not a few have to regret that their rapacity for knowledge was not moderated, in many reſpects, and, on many occaſions, not a few may juſtly envy a happy ignorance, of much, whoſe acquaintance has coſt them dear: theſe, while they are inſtances of a general deſire of knowledge, are alſo proofs of the neceſſity that it ſhould be directed by ſagacity and virtue; that it is not the quantity but the quality of information which renders it valuable. Knowledge is a remedy for diſeaſes of the mind; but who takes remedies indiſcriminately? Knowledge is like decoration,—in its juſt place, in its proper time, in its happy application,—elegant; but diſ-

guſting, if compoſed of ſhreds and patches, if polluted by filth, or contaminated by infection.

Not to knowledge contaminated by infection, or polluted by filth, are you now invited; not to an entertainment of flattering but poiſoned viands; not to preſent pleaſure, ſucceeded by future woe: I moſt willingly hope your ſatisfaction will be COMPLETE; that while I ſpeak, you will be entertained; that on recollection, you will be benefited; that no ſigh at time loſt, no regret at learning—to be unlearned, will ever ſucceed the attention you are pleaſed to beſtow on the ſubjects I ſhall offer to your notice.

Nor do I think, that merely to do no harm, to diſſeminate no evil, to propagate no injurious principles, that *negative* virtue only ſhould content thoſe who deſire to poſſeſs valuable information. It ſeems to be our duty to unite moral improvement to natural ſcience. Is it not deſirable, to become better as we become wiſer? Methinks I would willingly learn more than one leſſon; and while, by conſideration and ſtudy I improve my underſtanding, why not alſo amend my heart? If I learn greater complacency of mind, greater equanimity of conduct, greater ſerenity of temper, greater humanity of deportment, greater benevolence toward man, greater piety toward God, the acquiſition is important, and the occaſion of it happy. If, when I ſee the general care of Providence over its works, how it has fitted them to their ſtations, and their ſtations to them, how it preſerves and maintains them throughout innumerable revolutions, how it continues their order,

ſuffers no chaſm, no extinction, no deficiency,—If, when I remark this, I become more reſigned, more contented, more humble, who will deny my advantage? If, when I reflect how ferocious animals are baniſhed to arid deſarts and to ſultry waſtes, I learn to moderate every ferocity in my own breaſt, am I not improved? I will avoid the hiſs of the ſerpent, leſt I be thought to poſſeſs his venom; I will fan no one to ſleep while I ſuck his blood, ſo does the noxious bat; I will couch for no one, and then ſpring on my prey; it marks the cruel tyger: rather, while I live—be my labours of ſervice, like thoſe of the generous horſe, or the patient ox; when I die—be they uſeful as the fleece bequeathed by the uncomplaining ſheep.

If there be any perſon ſo profoundly ignorant, or ſo wantonly malevolent, as to deny the moral advantages ariſing from natural ſcience, yet let ſuch an one acknowledge that he is daily beholden to his acquaintance with it for innumerable benefits. By what are we informed of the proper periods of reſt and repoſe? who appoints the returns of ſeed-time and harveſt? what harbinger relates the expected changes from heat to cold, from cold to heat? who regulates the returning tide? who meaſures the lapſe of time? I confeſs, the ruſtic may enjoy effects, without underſtanding their cauſes; the ſailor may tide down his paſſage, without perceiving the origin of the riſing flood: Yet, to theſe very perſons a knowledge of the principles connected with the element they manage, *could* do no harm,

might

might prove extremely uſeful, and *muſt* be a ſource of conſtant pleaſure.

But to thoſe whoſe circumſtances in life permit as amuſement, that they may employ their time in elegant ſtudies, or to thoſe whoſe occupations require entertaining intervals, nothing can be more ſuitable than ſuch SURVEYS of NATURE as I mean, in the progreſs of this undertaking, to offer for your reflections; and, perhaps, the time may come, when the recollection of a hint now delivered, may afford ſignal benefit to ſome of my auditory: It may, perhaps, aſſiſt in diſtreſs of body, or exigence of mind; may contribute to freedom from diſeaſe, or deliverance from ſuperſtition.

How often have I pitied thoſe days of ignorance, when credulity was impoſed upon by pretended magic! when natural ſcience ſeemed productive of effects beyond human ſkill! when the enamel ſwan followed the magnetic knife which offered bread,—this way—that way, as if ſenſible of the food, and ſolicitous to peck at it. I conceive, with a mixture of pity and regret, the exclamations and ſurpriſe of the beholders: but pity and regret increaſe, when we conſider to how many illuſions ſuch knowledge has given ſupport, what advantages have been taken by predicted eclipſes, by ignited vapours, by oracular ſpectra; and theſe too, in all ages and parts of the world, not confined to the ſacred oak, or to the ſounding ſtatue of Memnon.

Happily theſe days of obſcurity are (to us) ceaſed; we do not take upon truſt the blood of Adonis (or "Thammuz

"yearly

"yearly wounded"), but inquire if the river is not ſubject to floods, and if no red clays line its banks. We worſhip not the Nile as a divinity, for its increaſe, but point to the clouds deſtined to augment its waters: No, nor do we tremble at the prolonged vapours of the cometary tail, or conſider them as ominous; but calmly take our glaſſes, and examine their appearance. Is natural knowledge then of no benefit to mankind? or is it a light advantage to be delivered from the thraldom of portents and prodigies?

That ſuperior power accompanies ſuperior knowledge, appears from no inſtance, that I recollect, more remarkably, than from the conduct of the Indians on the diſcovery of America. In one of his early voyages COLUMBUS had ſuffered by a ſtorm, his veſſel was in diſtreſs, his proviſion exhauſted, and his proſpect, as well as his ſituation, very deplorable; for the Indians brought in no ſupplies: but COLUMBUS knew they were ignorant, and, of courſe, that they were ſuperſtitious: hereupon he threatened them with vengeance and deſtruction, with no leſs than an utter extinction of their Moon; and this, ſays he, *in a few hours.* The Moon was one of their chief divinities, they doubted not its power to withſtand his enchantments, and relied on its continued effulgence; but when the eclipſe began, and the Lunar light diminiſhed, terror ſat in their faces, and dread ſunk their hearts; they beſought COLUMBUS to reſtore to ſplendour their darkened planet, and purchaſed the liberty of their divinity with ample preſents.

Reflect,

Reflect, I requeſt you, LADIES and GENTLEMEN, on this relation: had theſe Indians never before ſeen an eclipſe? they muſt have ſeen many. Had they never obſerved the gradual increaſe of the ſhadow, and the gradual recovery of the light? Wherefore then were they ſo terribly alarmed, when a little longer patience would have diſpelled their fears? Becauſe they were ignorant of its principles; they did not ſee what was before their eyes, nor recollect, nor reaſon, nor combine, nor calculate; and yet, in the ordinary length of life, they could not but have had opportunities. I forgive them their fears at what they had never ſeen before,—thunder and lightning directed by the hands of men. I forgive them, that having no quadruped of equal dignity, they conſidered a horſe as a ſwift divinity; that therefore they beſought its favour, and ſolicited its kindneſs, by preſents of bread and fleſh, by adorations and genuflexions; but that they ſhould ſuppoſe a mortal, like ourſelves, capable of controlling the heavenly bodies, is a ſtriking inſtance of human ignorance and inconſideration! But not all were equally inconſiderate: it was noble reaſoning (reported by the royal hiſtorian, GARCILASSO DE LA VEGA) of one of their Incas; 'I cannot,' ſays he, 'regard the Sun 'as a deity, for he ſeems controlled by neceſſity, and to 'have no freedom of will; he riſes and he ſets, and runs the 'ſame round perpetually, and without deviation; if he was 'at his liberty, he would ſurely ſometimes vary either his 'diſtance, or his courſe; which as he does not, I conclude 'he is obedient to ſome ſuperior being.' Such latent powers

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the human mind poſſeſſes; but without cultivation, how ſhall they ſpring forth? even the moſt ſimple and ordinary elements of our lives, with which we are intimately converſant, when ſomewhat varied from their uſual courſes, eaſily perplex the ignorant. Water is not capable of heat, thought the ſimple Otaheitean, when he poured his hands full from the boiling tea-kettle: "Water is not capable of ſolidity," ſays the ſun-burnt Weſt-Indian; "how falſely theſe Europeans report of their walking over its ſurface!" "Good heavens!" ſays a ſooty African brought to Europe, at the ſight of falling ſnow, "it rains white rain! no wonder the people are white!"

At a time when the Conclave were aſſembled at Rome to elect a Pope, the plague broke out in that city (the very name implies devaſtation and mortality); many of the Cardinals died, many forſook the city; but one abode calmly in his palace, continued his conduct as ordinary, and preſerved his dwelling from contagion: this was thought ſuch a miraculous diſtinction as implied divine election, and, accordingly, he was choſen Pope. What was his ſecret? ſimply this: he perceived that the diſorder was occaſioned by ſtagnated air; he knew that, in conſequence, a circulation of air would prevent it, and he knew that fire circulated air; the expence, therefore, of a few fires, to renew the aerial fluid, preſerved himſelf and his houſehold.

I ſhall be permitted to obſerve, that, in many reſpects, we, in theſe days, poſſeſs much knowledge, and many opportunities of knowledge, which former ages were unac-

quainted with:—we are not now, as ALEXANDER was on the banks of the Indus, terrified at the retreat of the tide, and ready to conſider it as the effect of divine anger; or, what would now be thought of a commander in chief, who, like CÆSAR, ſhould omit to provide againſt the ſpring tide at a full Moon? and yet this very omiſſion coſt Cæſar many veſſels, and riſked the whole expedition in his firſt voyage to Britain.

If we turn our inſpection to civil life, we muſt admit, that not only the materials of every manufacture, but alſo the principles of art, and of elegance, ariſe from the ſtudy of nature. In a commercial country, like this, I might remark that much of our very neceſſaries of life is the product of foreign parts; how ſhould we ever have profited by their uſe, had we continued ignorant of their qualities? We import cotton and ſilk for our dreſs, many kinds of edibles for food, and a variety of other articles that might be named. In the *materia medica* the uſe of an intimate acquaintance with nature is notorious and undeniable, and a liberal intercourſe throughout the globe is, here eſpecially, mutually and highly beneficial.

VOLTAIRE, indeed, has ſaid, 'it is pity the *quinquina* (Jeſuit's bark) grows in one climate, while the fever is the diſorder of another:' but had that ingenious wit recollected, that the neceſſity of intercourſe, and friendſhip, among all mankind is ſtrongly implied by giving to one climate what is neceſſary to another, he would rather have congratulated himſelf on being able to aſcertain, by experience,

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the virtues of the *quinquina*, than have murmured againſt the local appointments of Providence.

Indeed, I venture to ſay, that the more we become acquainted with the general diſtributions of Nature, the leſs of a repining ſpirit ſhall we indulge: that the highly exalted aromatic *might* have grown in the cooler climate of the north, is poſſible; but could it have acquired that vigour, that power, which its nearer reſidence to the Sun has imparted to it? or if, for the ſake of that, the ſolar heat had been augmented, what havock had it made among our milder fruits!

Should I mention the politer ſtudies of mankind, I muſt needs place an acquaintance with Nature and her productions, as the very foundation of every elegance: it produces a kind of inferior Paradiſe; wherein (as originally our firſt parent) WE may behold the infinite variety of creatures, and of objects, may acquire ſome kind of knowledge of their properties, manners, and diſpoſitions; and, by judicious obſervation and remark, may become informed of the natures and the number of our ſubjects without travelling over inhoſpitable deſarts and trackleſs waſtes, over mountains elevated above *aſcending* ſnows, over burning ſands, or over fields of ice.

There is nothing upon which I congratulate myſelf more heartily, than upon the eaſe with which information is now acquirable: When I fancy myſelf a companion of thoſe who explored the Andes; when from the ſummit of a mountain I ſurvey the clouds rolling *below*, the lightning

flaſhing

flashing *below*; when I hear the thunder bursting *below*, how interesting the scene! but when the piercing cold cramps the very bones, when the rarefied air render respiration difficult, but especially, when the descending mule brings all his feet to a point, when he stands reconnoitring at the brink of the precipice, when he *slides* down the mountain's side, league after league descending; without a guide, without a path, without a rein, without a possibility of turning, if wrong, and surrounded on every side by steep down gulphs——not even the Indian Huzza! keeps me from shuddering terror! Or when, on a wide extended desart of burning soil, I watch the course of some sandy cloud, when it advances, when it obscures the air, when it envelopes all around, I turn with regret from the general devastation, and rejoice that the dying groans are only imaginary; Or, if the *Samiel* breathe its pestiferous vapour, instant death! I rejoice that I need not prostrate myself to avoid it, or examine the joints of my companions if they retain life enough to *crack*. In my closet I fear not the fiery glare of northern meteors, nor the sultry beams of a vertical Sun, nor the destructive damps of deep-sunk mines. In my closet I defy the proboscis of the elephant, the roar of the lion, the rapidity of the tyger, the fang of the rattle-snake, the poison of the serpent: the hungry eagle excites no alarm, the rapacious condour no affright; the enormous whale, the ravenous shark, I survey,—but without dread: and, although unable to name every creature according to its properties, as ADAM did, yet, like

him, I form ſome kind of acquaintance with them, and enjoy a kind of dominion over every inhabitant of the globe.

Shall we be permitted to form an idea of what might be the natural knowledge of ADAM? did he ſtare at the Sun, as ignorant of his effects? did he diſregard the ſilver Moon? Rather, let us ſuppoſe, that he well knew the importance and magnificence of the ſolar light, the ſerenity and coolneſs of the Queen of Heaven; nor was he perhaps uninformed of thoſe remoter, yet neighbour worlds, the planets, or undelighted with the luſtre of the ſtar-beſpangled firmament. Certainly, we muſt admit his intimate acquaintance with himſelf, and the regions of his immediate dominion: The air, the light, the water, the earth, were ſo many diviſions of his kingdom, and alternately engaged his attention. He ſaw HIMSELF the only rational creature moving upon the earth; endowed with faculties capable of very extenſive comprehenſion, intelligent, and exact. Around him were the quadrupeds of various bulk; from that unwieldy mountain of fleſh, the elephant, to the moſt diminutive: poſſeſſing an infinite variety of diverſified qualities; courage and valour, ſagacity and cunning, wiſdom and prudence, ſtrength and perſeverance; diſtributed among them, not by chance, but in exact proportion; not united in one claſs, to the deprivation of others, but ſo regulated as to prevent both ſcarcity and monopoly. The feathered fowl delighted him with their ingenuity in the conſtructions of their habitations, with their melody in the

verdant grove, with their gay and ſprightly plumage. The inſect tribes excited his curious inſpection, and ſhewed in miniature the vivacity of the moſt ſplendid decorations; even the (now) reptile ſerpent had his many attractions, his vivid ſpots, his variegated ſcales, and peculiar ſubtlety "above every creature of the field;" nor was the vegetable world leſs important to him: the arbour which compoſed his dwelling, the trees which ſurrounded his habitation, thoſe from whence he gathered his ſuſtenance, could not but be familiar to his remark. The various fruits, of fragrant ſmell, of ſimple taſte, of poignant reliſh; the various leaves, broad or narrow, downy or ſmooth; the flowers, whoſe odour refreſhed his ſpirits, and regaled his ſmell, while they delighted his ſight, and charmed his view, by their beauty and variety. What might be his knowledge of the inhabitants of the waters, we know not: *We* find them well deſerving our inveſtigation.

What forbids us from endeavouring to be as wiſe as ADAM? The pleaſures ariſing from this wiſdom may perhaps be diminiſhed, but are by no means deſtroyed; they yet remain, as among the natural, ſo among the moſt conſiderable, enjoyments of mankind; they are our pureſt pleaſures, and, in regard to advantage, we have ſome (and very forcible) reaſons for the ſtudy now, which exiſted not in the ſtate of innocence; for now many brute animals are deſtructive; theſe we muſt learn to avoid, to conquer, or to tame: many trees are poiſonous, many fruits deadly, many plants noxious, theſe we muſt learn to diſtinguiſh,

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leſt our food become fatal, and leſt we miſtake diſeaſe for health. We muſt now avoid the inſect, unleſs we are certain it has no ſting; we muſt forbear the flower, unleſs we are ſure its fragrance is not injurious; not only ſo, but the phenomena which ſurround our earth, the air, the meteors, are not as they were originally: we know ſtorms and tempeſts by experience; thunder and lightning, the rolling billows, the mountainous ſurge; and we alſo wiſh to inquire into their cauſes, and into their properties.

By the experiments of our predeceſſors, by the labours of many intelligent men, we are enabled to give reaſonable anſwers to queſtions on theſe ſubjects, and to acquire a competent knowledge of the operations of nature; not, indeed, that we pretend ability to account for all, or to develope every myſtery of nature: we admit that much remains hitherto unexplored, much that never will be explored. 'It is high as heaven, what can we do; deep as hell, what can we know.' Yet, from this our inevitable and inſuperable ignorance, we will take occaſion to acknowledge the greatneſs of the univerſal Author, and to confeſs our own humble abilities. We are not yet diſembodied ſpirits, we are not yet immortals at liberty, but ſurrounded by numerous wants, and tenants of tabernacles of clay.

Come then, my friends, to whom knowledge opens her copious ſtores, to whom liberal Nature offers her choiceſt treaſures, come, and, like rationals, enjoy rational ſatisfaction; inſpect the glorious Sun, the lucid Moon, or "kindle your

"devo-

" devotion at the Stars." Secure from the war of elements, inveſtigate their cauſes; for us the ſtorm ſhall roll, the thunder burſt, the lightnings flaſh; for us the waves ſhall roar, the yawning abyſs foam; the volcano ſhall emit ſulphureous ſmoke, and flames as from Hell; earth too ſhall tremble, while we feel in ſafety its percuſſions, and ſtand unmoved amidſt a falling world.

Or, if inclined for diverſion, we will indulge the ludicrous; will applaud the cunning of the fox, or ſmile at the grin of the baboon, or laugh at the grimaces of the monkey; will accompany their robberies, and enjoy the joke of a fruit-ſtealing expedition. For leſſons of domeſtic life we will admire the induſtry of the beaver, or the anxiety of the hen over her callow brood; we will viſit the laborious bee, and taſte the ſweets of honeſt diligence; we will pluck the bluſhing roſe, and gather every flower of the ſpring; we will cruſh the luſcious berry, and quaff the blood of the grape, without diſguſt, without repletion, without inebriety.

We may often learn rational information; birds who, to ſecure their neſts, hang them on the extreme leaves of trees, or thoſe, who make the rock their aerie, ſhall teach us prudence, and the half-reaſoning elephant ſhall raiſe our admiration. Not ſatisfied with this, we will turn inwards our inſpection, and when we there diſcover principles and qualities ſuperior to any beſtowed elſewhere, it ſhall excite our wiſhes, our reſolutions, our endeavours, to correſpondent dignity of ſentiment and deportment.

I would

I would have our SURVEYS of NATURE produce much ſuch effects as a certain circumſtance produced upon MOSES: Moſes was a well-informed Naturaliſt, 'was 'learned in all the wiſdom of the Egyptians,' and much more, which the wiſdom of the Egyptians could not teach him. When wandering among the foreſts of Midian, he ſaw a buſh (a palm-tree, if you pleaſe) burning, yet not conſumed; at firſt, we may ſuppoſe, he regarded it as an accidental conflagration; we may imagine him ſaying, 'the 'fire will ſoon be extinguiſhed, having burned down the 'tree;' but when no ſuch event enſues, when the brilliant ſplendour injures not the verdant buſh, it excites his attention, the inquiſitive ſpirit of the Naturaliſt prevails, and he reſolves to examine it. 'I will now turn aſide, and ſee this great ſight, wherefore the buſh is not conſumed.' You know the iſſue of the ſtory; that the contemplative MOSES became here the man of God, and the curioſity of the Naturaliſt ended in the devotion of the prophet.

LADIES and GENTLEMEN,

I beg to be indulged in adding a remark on the methods of ſtudying nature: I am very well aware of the force of regularity, that confuſion is every way hurtful, and order extremely beneficial; and yet, Nature has taken ſuch liberties, that order is by no means uniformly marked out, or uniformly aſſented to by Naturaliſts. Some have ſhackled themſelves by ſyſtem, and joined together what Nature had put aſunder; they have divided and claſſed, till the

members of ſome of their claſſes excite a ſmile. While others, aſſerting that Nature has no ſyſtem, ſuppoſe, that in having no ſyſtem themſelves, they follow Nature. Fair and ſoftly, if you pleaſe; all productions of Nature are not alike—in proportions, in ſize, or in manners; their differences, I mean the moſt obvious, may therefore diſtinguiſh between them, and thoſe which are neareſt allied to each other, may juſtly be arranged together.

For my own part, I propoſe no very cloſe arrangement in the courſe of theſe Lectures, but ſhall do my endeavour that the interval between the preceding and the following may not be too extenſive, that I may not ſeem to *jump*, at leaſt, without obvious occaſion; but that, what is previouſly ſuggeſted, may open a way for the eaſy introduction of ſubſequent remarks. And I ſhall eſteem myſelf happy, if what I may have the honour to propoſe ſhall be found ſufficiently regular, familiar, and intereſting, to be treaſured up in your memory, and eſpecially, if it prove beneficial in your future ſituations in life.

LECTURE II.

"O thou that with ſurpaſſing glory crown'd,
Look'ſt from thy ſole dominion like the God
Of this new world; at whoſe ſight all the ſtars
Hide their diminiſh'd heads: To thee I call,
But with no friendly voice, and add thy name,
O SUN! to tell thee how I hate thy beams,
That bring to my remembrance from what ſtate
I fell,—how glorious once above thy ſphere,
Till pride and worſe ambition threw me down."

Paradiſe Loſt, Book IV.

SUCH, LADIES and GENTLEMEN, was the addreſs of the malignant ſpirit to our ſplendid luminary; of whoſe beneficial effects *we* entertain the moſt honourable opinion; without one diſſenting voice, aſcribing to the Sun innumerable and invaluable influences.

If idolatrous worſhip may be in any degree palliated, that paid to the Sun ſeems to have had the greateſt ſhew of reaſon to urge in its defence: without his irradiating beams, what were the globe we inhabit but a cheerleſs void? without his invigorating heat, it were an idle waſte. How melancholy would be all mankind, had they intelligence that at ſuch a time his ſplendour would become extinct, or that he would ſet to riſe no more!

As it is, and under no ſuch apprehenſions, we part with him with regret; and were not his abſence the time for repoſe, and repoſe indiſpenſable to our wearied nature, we ſhould never willingly forego the light of the Sun: Very juſtly, therefore, may he claim pre-eminence in our eſteem, and the firſt engagement of our thoughts; accordingly, I mean, at this time, to requeſt your attention, LADIES and GENTLEMEN, to a few remarks on the ſolar luminary.

That circumſtance which, in the firſt place, diſtinguiſhes the Sun from every object around us, is his LIGHT; this firſt ſtrikes us, and is ſo neceſſary, and pleaſant to us, and ſo peculiar to this heavenly orb, that we pity thoſe eyes that never beheld the Sun.

It is natural, therefore, to inquire of what is this fountain and ſource of light compoſed? In reply to which queſtion, I beg leave to premiſe, (1) that we have nothing on earth, in any degree, comparable to it, ſo as to determine its properties by compariſon; for as our earth is an opaque body, void of native light, it affords no example perfectly applicable; (2) what we call fire, or light, what fire or light we on earth may be ſuppoſed to poſſeſs, is not elementary, but groſs, terreſtrial, and impure, even after we have made every allowance and diſtinction between fuel and fire; therefore, (3) that we can only conjecture on this ſubject, and ſupport our conjectures by the analogy of ſuch ſubſtances or circumſtances as come under our examination.

We may conceive of any matter whatever as either a ſolid, or a fluid. Solidity, you know, LADIES and GENTLE-

MEN, is ſuch a fixity of parts, as does not permit the motion of one over others: You cannot, in puſhing a ſolid body, puſh what parts of it you pleaſe, but muſt, of neceſſity, puſh from you the whole of ſuch a body; whereas, of a fluid, you may roll over and over again, may diſplace and remove, any of its parts: As in water, you may agitate the ſurface without moving the bottom; you may even furrow one part of it, and yet a diſtant part be unaffected. By the bye, we are apt, when we inſtance a fluid, to take up the idea of water, that fluid being our moſt intimate acquaintance: we ought rather to recollect that there are fluids of much greater weight and compactneſs (*ſubſtance* ſhall I call it?) than water; certain chemical ones we know are ſo, quickſilver, or mercury, we know is ſo (fourteen times heavier than water), and continuing this progreſs, we may eaſily conceive of a fluid extremely denſe and ſubſtantial, and yet permitting a motion of a part or parts of its quantity without diſturbing the reſt; whereby it will ever be diſtinguiſhed from a ſolid.

Of ſome ſuch fluid the Sun is preſumed to be compoſed; a cloſe, adheſive fluid of light; a *conſolidated* fluid is, I acknowledge, an improper expreſſion, yet it may ſerve to impart an idea of a fluid ſo compreſſed, ſo united, as to leave ſcarce any vacancy between its component particles; conſequently, the ſame extent of ſpace may contain a very great many more of ſuch particles, than if they were looſe, and at a diſtance, or ſeparated, in any degree, from each other; we will only ſay at preſent ten times as many; conſequently alſo, if any given number of particles be ſuppoſed to quit this incorporated

aſſemblage, in a given time, it will be ten times as long before ſuch a compreſſed body is exhauſted.

A fluid may be thought more eaſily acted upon than a ſolid, its parts more eaſily ſeparable, and, when ſeparated, more divergent: Water is eaſily acted on; the very paſſage of the air over it, deprives water of ſome of its particles, and its vapours ſpread every way; very evidently, much further than duſt, or any ſimilar ſubſtance, flies from a ſolid body. The fluid, therefore, of which the Sun is compoſed, is adapted to *give off* its particles; but, in order to improve this diſpoſition of the Sun to *give off* its particles, in order to impel theſe particles with vigour ſufficient to quit the main body, to which they naturally adhere, and by which they are attracted, and held, there muſt be ſome force uſed, ſome active and vigorous motive muſt *drive* them from their native abode; and this impulſe we find in a ROTATION *of the ſolar orb upon its proper axis.*

Give me leave here to remind you, LADIES and GENTLEMEN, that however adapted may be our viſual powers to the nature of the globe we inhabit, yet, we muſt not expect to find them competent to the examination of diſtant worlds; on the contrary, they often deceive us, and generally, perhaps always, fail in their information. It is true, the Sun ſeems *round*; his outline, I ſay, is round, yet, for aught we know, that part of him, which more immediately faces us, might be flat: he might reſemble a very large diſh ſet at a diſtance, and be merely a flat body of a certain thickneſs, without any revolutory motion. I freely confeſs, I think, that had he been

been ſo, we ſhould have had little occaſion to thank him for his reſplendence; it is exceedingly probable we ſhould ſcarce have ſeen him. But, if we ſuppoſe him a globe, and revolving on his axis, we ſuppoſe a power which cauſes inceſſant agitation and motion (among his exterior particles eſpecially), and which by its conſtant and perpetual activity, *ſhoots* his luminous beams in every direction around him.

[The ſun revolves about his axis in twenty-five days, fifteen hours, ſixteen minutes.]

Let me here obſerve, that of all matter hitherto known or examined, light is compoſed of the *ſmalleſt* particles; they are the moſt minute and *atomical*: and of all globes hitherto explored, the ſun is immenſely the largeſt and moſt capacious, being 793,000 miles in diameter; his ſuperficial contents 10,000 times the ſurface of the earth: a momentary reflection is ſufficient to evince, that the rapid revolution of a globe ſo prodigious, muſt have moſt powerful effect upon particles ſo diminutive; it muſt hurl them through every ſpace of free ethereal medium, and nothing can obſtruct their progreſs, but ſuch opaque and ſolid bodies as forbid their penetration. Yet even by them they ſcorn to be confined, and rebound, diverging every way; ſuch reflected light it is which ſhews us the moon, and the planets of our ſyſtem, they ſtopping the paſſage of ſo great a quantity of light, that even when reflected on all ſides, it is ſenſible through a very extenſive diſtance.

I requeſt the attention of my auditory to what I juſt hinted of the MAGNITUDE of the ſun; and, as cloſely connected with it, his SITUATION *in the ſyſtem*. I may here obſerve, that

according to the advances of ſcience, the magnitude of this luminary is calculated proportionally greater than formerly; which proves, not that former principles were erroneous, but that they were not perfected by ſuch accuracy and advantages, as modern times poſſeſs.

The ſolid bulk of the ſun is eſtimated at one million times the ſolid bulk of the earth; his ſurface, at ten thouſand times the ſurface of the earth; his diameter, ſeven hundred ninety-three thouſand miles.—Dimenſions worthy our admiration! It ſeems at firſt ſight, as if here was a waſte, a redundance: might not a ſun of leſs magnitude have ſufficed, have equally diſpenſed its beams, excited heat, and have been equally beneficial? Light and heat a ſun of ſmaller magnitude *might* have communicated; but it would not therefore have been equally beneficial. Recollect what was juſt now remarked of the impulſe of light; ſmaller dimenſions muſt imply ſmaller power. Beſides this, modern diſcovery affords a ſatisfactory anſwer to the queſtion, having demonſtrated, that all large bodies attract ſmaller; that all ſmall bodies gravitate toward larger; that the more are the contents of a large body (*i. e.* the more compact, cloſe, and denſe its particles), the greater is its attractive power; it follows, that a ſun of diminiſhed magnitude would have been proportionally weakened in its effects on ſurrounding bodies. We will ſuppoſe, if you pleaſe, that the ſun were ſuddenly ſhrunk to the dimenſions of our earth; the order of the heavens would ceaſe, the ſun would be drawn from his ſtation, and the larger bodies around him would attract him toward themſelves. Shall we add to the ſuppoſition,

that our earth was ſuddenly enlarged to the dimenſions of the ſun; in this caſe it would become the centre of the ſyſtem, and merely by its magnitude would attract toward itſelf every revolving planet.

The idea of attraction is extremely ſimple: ſuppoſe a body containing ten particles, it will attract a body containing but one particle, with ten times greater power than that ſingle particle will attract the body of ten particles; as a body of one hundred particles will attract the one of ten, and ſtill by very much greater power, the ſingle particle. It was neceſſary therefore, that the ſun ſhould be immenſely large, that his dimenſions might forbid every diſpute or rivality, that he might maintain his ſtation immoveably, and that his attraction might reach to the very extremity of the ſyſtem. What the ſolar ſtation is, I think is not difficult to conceive; ſince reaſon would incline us to imagine, that the largeſt and moſt attractive body muſt be placed in the centre; around which the ſmaller muſt circulate: moreover, the ſource of light ſeems moſt properly there to be expected. In fact, the ſun is the centre, the focus of the ſyſtem: and around him circulate the planets, and their attendants (one of theſe planets is our earth); all at ſuch regular diſtances, and proportionate intervals, as counterbalance the effect of ſolar attraction, which conſtantly weakens, as diſtance increaſes. From the ſun then, we calculate the diſtance of his attendant planets, and therefore the diſtance of the ſun from the earth, &c. is rather an improper expreſſion; the diſtance of the earth *from the ſun*, will be noticed in its place.

Thus we have conjectured, at the nature of the ſun's body,

at his globular form, at his immenſe magnitude, at his central ſtation: we ſupport ſome of theſe conjectures, by informing you, that he is not always every where equally luminous, but that many SPOTS have been obſerved on his ſurface. I remember a baker's man exclaiming, "Maſter! Maſter! do come and look, there's a hole in the ſun;" "Aye, John, that I will," replied the maſter, "what's on t'other ſide?" The ſpot which occaſioned the outcry, was ſurely large enough, for I remember ſeeing it with my naked eye, and that diſtinctly: it was (really) at leaſt five times the ſurface of the earth. They are ſeldom ſo large as this was, but very much ſmaller; their magnitudes vary, as alſo their forms; and both their magnitudes and forms change, even while ſubject to obſervation.

In moſt of theſe ſpots there is a deep black *nucleus* (or kernel) ſurrounded by a duſky cloud, whereof the inner ſkirts next the black are ſomewhat brighter than the outſkirts; they change their ſhapes, not unlike the manner of our clouds, only they take longer time about it, ſometimes a few hours, ſometimes days; ſometimes a ſpot breaks into two or three; ſometimes two or three unite into one; ſometimes they are very numerous on the body of the ſun together; ſometimes they do not appear for a conſiderable time, but ſeem perfectly diſſolved. But the principal circumſtance of all, is their motion, which carries them over the diſk of the ſun. They ſeem to enter the ſun on his eaſt ſide, and gradually croſſing his whole face, they go off on his weſt ſide. Now, as there may be twenty or thirty of theſe ſpots at once, and all follow the ſame motion from eaſt to weſt, it implies very ſtrongly, that

ſuch

ſuch is the motion of the ſun's body. Indeed we are beholden to them for the information that the ſun has ſuch a motion; and alſo that he is a globe and not flat.

In looking at any flat object, acroſs which a body moves with uniform velocity, you ſee it move *ſtrait*; moreover, it ſeems in every part of its courſe to move equally quick, ſo that on either ſide as in the middle, it ſeems to make juſt the ſame ſpeed; as when I move my watch acroſs the flap of the table, you perceive no difference of velocity in the parts of its courſe; but when I move the ſame object round a globe, it ſeems to move quicker on that part of the globe neareſt to you, and moſt directly oppoſed to you (which I might call its protuberance,) and ſlower on the ſides, or receding parts (this obſervation we ſhall have occaſion to conſider hereafter); exactly ſo are the ſolar ſpots; they come on ſlowly, and increaſe in their ſwiftneſs, but their ſwiftneſs decreaſes as they advance to the extreme edge of the ſun, and are about to get on his hinder parts. Another remark if you pleaſe; in moving my watch round the globe, you obſerve that it is only when directly oppoſed to your view on the protuberant part of the globe, that you ſee the dial plate to be a circle, or could tell the figures, but as it moves off, the dial plate becomes oval, and the figures confuſed; much ſuch a change do the ſolar ſpots undergo, becoming narrower as they approach the edge of the ſolar diſk, till at laſt they become very thin, and diſappear.

It is natural to ſuppoſe that theſe ſpots move in the regular courſe of the rotation of the ſolar orb, *that* is no doubt perpendicular to his axis; had they moved vertically, they would have

proved his axis horizontal; had they moved horizontally, they would have proved his axis vertical; but as they appear to move in a line ſomewhat inclined to, and only *nearly* horizontal, they prove the ſun's axis is not perpendicular, but inclined (to the plane of the ecliptic) about ſeven degrees and an half.

There are various opinions about the nature and formation of the ſolar ſpots; ſome have ſuggeſted, that the ſun has an internal nucleus, opaque, mountainous, and uneven, as our earth is; that this nucleus is covered over with a fiery luminous fluid, whoſe ebbing or flowing may occaſionally lay bare the tops of the mountains, &c. adjacent, and conſequently theſe appear like black ſpots. Others think, that ſuch a nucleus may contain volcanoes, which ejecting from time to time vaſt quantities of bituminous ſubſtances, they, and their ſmoke, &c. occaſion the ſpots we mention; that as theſe volcanoes exhauſt themſelves, the ſmoke diminiſhes, and being fired by the ſun, become brighter than the parts around them: for they obſerve, that the dark ſpots termed *maculæ*, are uſually ſucceeded by extraordinary ſplendour in the ſame parts, which ſplendid ſpots they term *faculæ*. Others gueſs, that in the fiery fluid are immerſed huge opaque bodies of irregular ſhapes, which riſing to the ſurface from time to time, form ſpots; while others ſuppoſe, that as in melted metals, the ſcum riſes to the top; ſo the fluid of ſolar light being in perpetual agitation (this we have ſaid is very probable), raiſes the groſſer parts in various forms, which at length it diſſipates or reabſorbs.

There

There is great reaſon to conclude, that the ſun is encompaſſed with an ATMOSPHERE of light; either the ether which immediately ſurrounds his body, heated ſo highly as to become luminous, or fiery particles emitted from him, and retained near him by his attractive power. It muſt not be omitted, that not only there is of neceſſity a much greater number of particles near him, before they are diverged every way into the vaſt expanſe; but alſo, that in our inſpection of this luminary, his rays cannot but be *fore-ſhortened*, and conſequently more ſenſible as they approach his body.

The *face of the ſun* when clear of ſpots, ſeen by the naked eye through a ſmoked or coloured glaſs, or through the vapours near the horizon, (the effect of theſe mediums is only to take off the refulgence of his rays, and thereby permit the eye to bear the ſight of the luminary) ſeems all over equally refulgent; but through a teleſcope, the middle or protuberance of the diſk, from whence the light is darted upon us more directly, ſeems the moſt ſplendid, as is natural to expect it from a globe. When there are any *faculæ* toward the edge of the diſk, being on a deeper ground, approaching to *demi-tint*, they conſequently ſeem brighter and more diſtinct.

Does the ſun diminiſh? Is he perpetually ſupplying light around him, and yielding the important fluid without reſtitution? if ſo, does he not waſte? In the firſt place, conſider the ſurpriſing ſmallneſs of the particles of light; how many myriads may be compreſſed into an inch ſpace of *ſolid* light, we know not; next conſider the immenſe ſuperficies of the ſolar orb; if ſuch a globe be diminiſhed throughout one mile,

or ten miles, in the courſe of years, or a much greater depth, yet it bears ſo trivial a proportion to the globe itſelf, that no poſſible obſervations could detect it. Perhaps alſo there is no matter really *annihilated* and totally loſt, perhaps there may be ſome circulation of this fluid, which having performed its office throughout the expanſe, may be returned to its celeſtial origin; perhaps from diſtant ſuns, perhaps from revolving comets; but if not, ſtill ſo ſmall a decreaſe of the ſun will not prevent his laſting for ages of ages.

The proverb ſays, "The ſun cannot be looked upon ſted-"faſtly;" and we muſt acknowledge, that our viſual powers are incompetent to an accurate inſpection of this luminary; but while our natural organs are weak, and merely adapted to the place of our abode, our intellectual faculties, which elevate human dignity above its fellow-creatures, appear to great advantage in thoſe contrivances, and reaſonings, by which we inveſtigate ſuch immenſely diſtant and wonderful objects. Our ſenſes are confined, but our ideas are free; *they* range without control over the univerſe itſelf; and it is our own faults if they return not with treaſures of wiſdom.

The object we have been contemplating this evening, may well contribute an ample ſhare to ſuch treaſures: this, LADIES and GENTLEMEN, is our conſtant friend, not merely paying us occaſional viſits, but perpetually exerting his good offices on our behalf; nor are his viſits thoſe of ceremonial politeneſs only; ſubſtantial benefits ever attend his preſence: joy and hilarity are excited by his appearance, the whole creation awaits his approach, and welcomes daily his

return;

return; his favours are diſpenſed without partiality, are free as they are important, liberal as they are neceſſary; and diſtributed with unreſerving bounty to every atom of life: this is the benevolent diſpoſition of the ſun; if at any time he is obſcured from us, it is by our own clouds; if his luſtre is ever veiled, it is by terreſtrial vapours; the fault lies not in him, but in ourſelves, and we will not ſuffer ſuch interruptions to prevent our gratitude.

Gratitude is the effect of a juſt ſenſe of favours received; if we undervalue them, we are ſo far ungrateful, and cenſurable; if we overvalue them, we are ſo far verging to idolatry. If we diſtinguiſh not the real ſource of our benefits, our gratitude is miſplaced; and this very ſubject is a proof what dangers ariſe from a miſtake ſo unhappy, ſince the ſun himſelf is a ſervant, not the Maſter, a creature, not the Creator. Yet there is ſomething more amiable in acknowledging the benefits we receive, though erroneous as to their author, than being inſenſible of them, and never raiſing an adoring eye to the Heavens which furniſh them: here we pity error, but there we deteſt ingratitude: and while we perſonally wiſh to be equally diſtant from both, and while miſ-directed ſuperſtition cannot be ſufficiently exploded, I think we may ſafely own, it is preferable in many reſpects to brutal and thankleſs atheiſm.

We began this Lecture by ſaying, if idolatry might be palliated, it muſt be in the worſhip of the ſun; and it is true, that the ſun to the dazzled eyes of mortals, ſeems in many reſpects, if not divine, a fit type of divinity; but we ſhall find a

compariſon, let it be as ſlight as we will, infinitely to the diſadvantage of the luminous orb. The ſun has his *ſpots*; but "God is light; and in him is NO DARKNESS AT ALL:" if we cannot bear the light of the ſun, but muſt interpoſe denſer mediums to moderate his rays, what wonder no fleſh can ſee HIS face "who dwelleth in light inacceſſible and full of glory?" The ſun too has his inclination, and his revolutions; but "with the Father of lights is no variableneſs, nor ſhadow "of turning;" no change, no viciſſitude. I confeſs the magnitude of the ſolar orb is great; he ſhoots his rays far, very far, but they diminiſh in power and effect, by diſtance: Whereas Deity is omnipreſent, omnipotent, his effulgence univerſal and undiminiſhed. Nor let the ſun boaſt of perpetuity; there was once a time, when he ſhed no ray, nor imparted light to any gladdened world; there ſhall return a time, when he ſhall be extinct, when his ſervices ſhall be diſmiſſed, and his lamp extinguiſhed. This may be diſtant, very diſtant, but when ten thouſand times ten thouſand ſuns, his ſucceſſors, ſhall like him have expired in darkneſs, Deity ſhall be no nearer termination, ever, as before, perpetual; the only juſt object of veneration, of reverence, and of love!

OBSER-

SPOTS in the SUN.

Fig. 1.

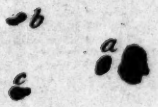


Fig. 2.

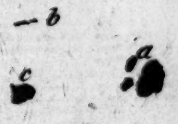


Fig. 3

Fig. 4.

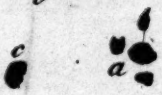


Fig. 5.

Fig. 6.

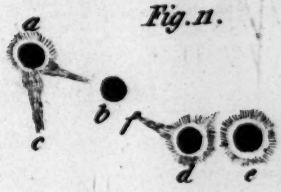
Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 11.



OBSERVATIONS on the PLATES Belonging to LECTURE II.

PLATE I.

THE figures of this plate ſhew the various and uncertain forms aſſumed by the ſolar ſpots, and their perpetual changes.

Fig. 1. A ſpot ſeen on the ſun, June 27, 1703, at between nine and ten o'clock in the morning, wherein we obſerve *a* is a triangular ſpot accompanied by two leſſer ones, *b* and *c*.

Fig. 2. The ſame ſpots ſeen at four o'clock in the afternoon of the ſame day, *a* appears to have loſt its triangular ſhape, and a fragment is broken from it; *b* is become thinner, and *c* is augmented in dimenſions.

Fig. 3. The ſame ſpots at half after five o'clock: the fragment from *a* is itſelf divided into two, the ſpot *b* very narrow, and ſcarce viſible.

Fig. 4. At half after ſix o'clock, the ſpot *a* broken into another fragment *c* much enlarged.

Fig. 5. The ſpot *a* ſeen the next morning about ſeven o'clock, very greatly varied in form, and a new ſpot below it at *b*.

Fig. 6. The ſame at ten o'clock: the ſpot *b* augmented in bulk, and a ſmall ſpot additional.

Fig. 7. and 8. Spots ſurrounded by a yellow miſtineſs, from whence iſſue rays, which give them almoſt a ſpider-like appearance.

Fig. 9. and 10. The ſame ſpots further varied.

Fig. 11. Are ſpots ſurrounded with nebulæ (or cloudiſhneſs): the ſpot *b* was ſeen ſometimes very black, ſometimes fainter: *c* and *f* ſeemed like ſmoke, varying in ſtrength, appearing and vaniſhing often; *b* diſappeared firſt: *a* remained ſome time longer, perpetually changing its form and force.

PLATE II.

Fig. 1. and 2. Repreſent the general path of the SOLAR SPOTS; and from thence it appears, that they moſtly keep about the middle of that globe, ſeldom appearing near either his north or ſouth extremity; but though not uniform in the lines of their progreſs, yet on the whole, obſerving a general path.

Fig. 3. 4. and 5. Are repreſentations of the courſe of a cluſter of ſmall ſpots, and their variations in their progreſs; it appears evidently that they are ſubject to no control in their motions, but move freely in every direction, according to any impulſe they may receive; which therefore demonſtrates that they are immerſed in a fluid, not fixed in a ſolid body. Their continuance, as well as their forms, is extremely uncertain; the longeſt duration obſerved has been ſeventy days; but ſometimes they laſt ſcarce twenty-four hours.

Fig. 6. Shews a ſingle well-defined ſpot; on which we obſerve that in conformity to the principles in the LECTURE the daily interval decreaſes as the ſpot quits the centre: from twenty to twenty-three, being ſcarce the diſtance from ſeventeen to eighteen, agreeable to the appearances on a globe.

North

Fig. 1.

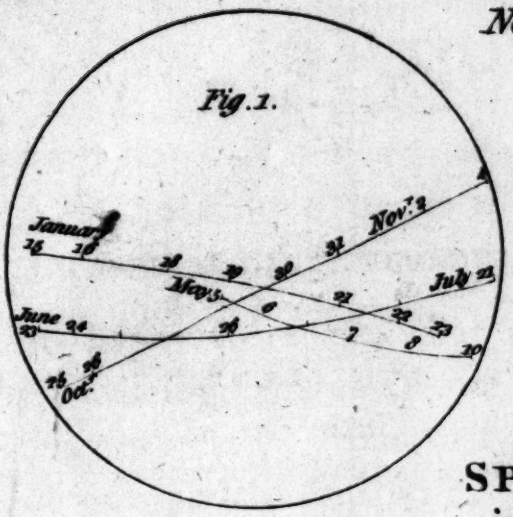
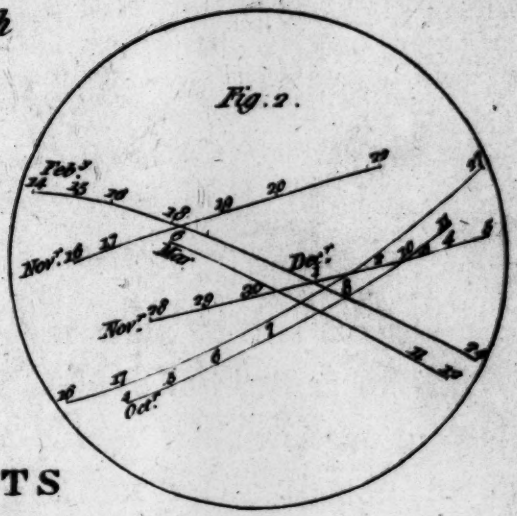


Fig. 2.



SPOTS in the SUN.

East

Fig. 5.

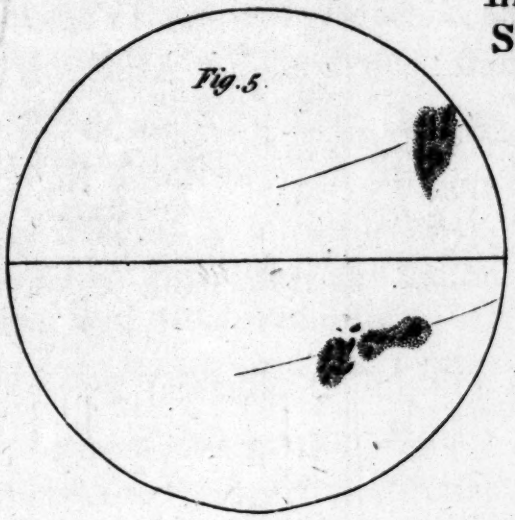
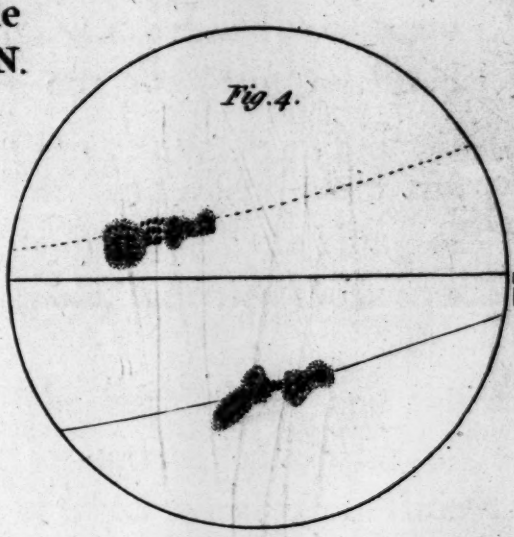


Fig. 4.



West

Fig. 3.

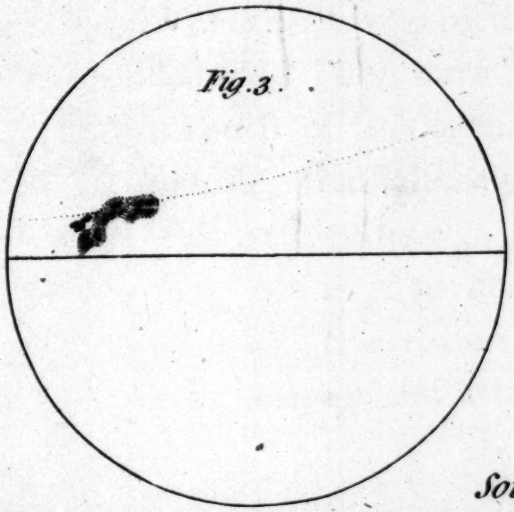
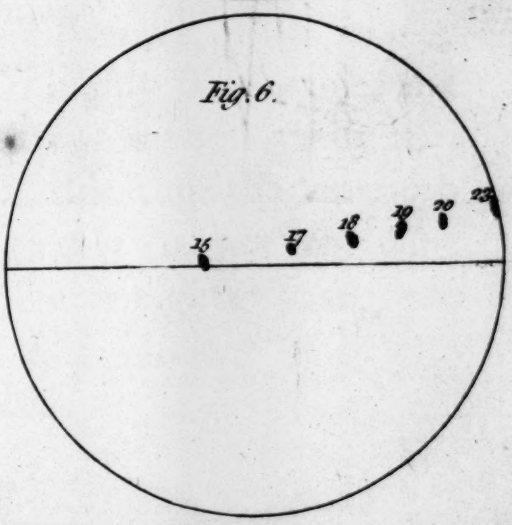
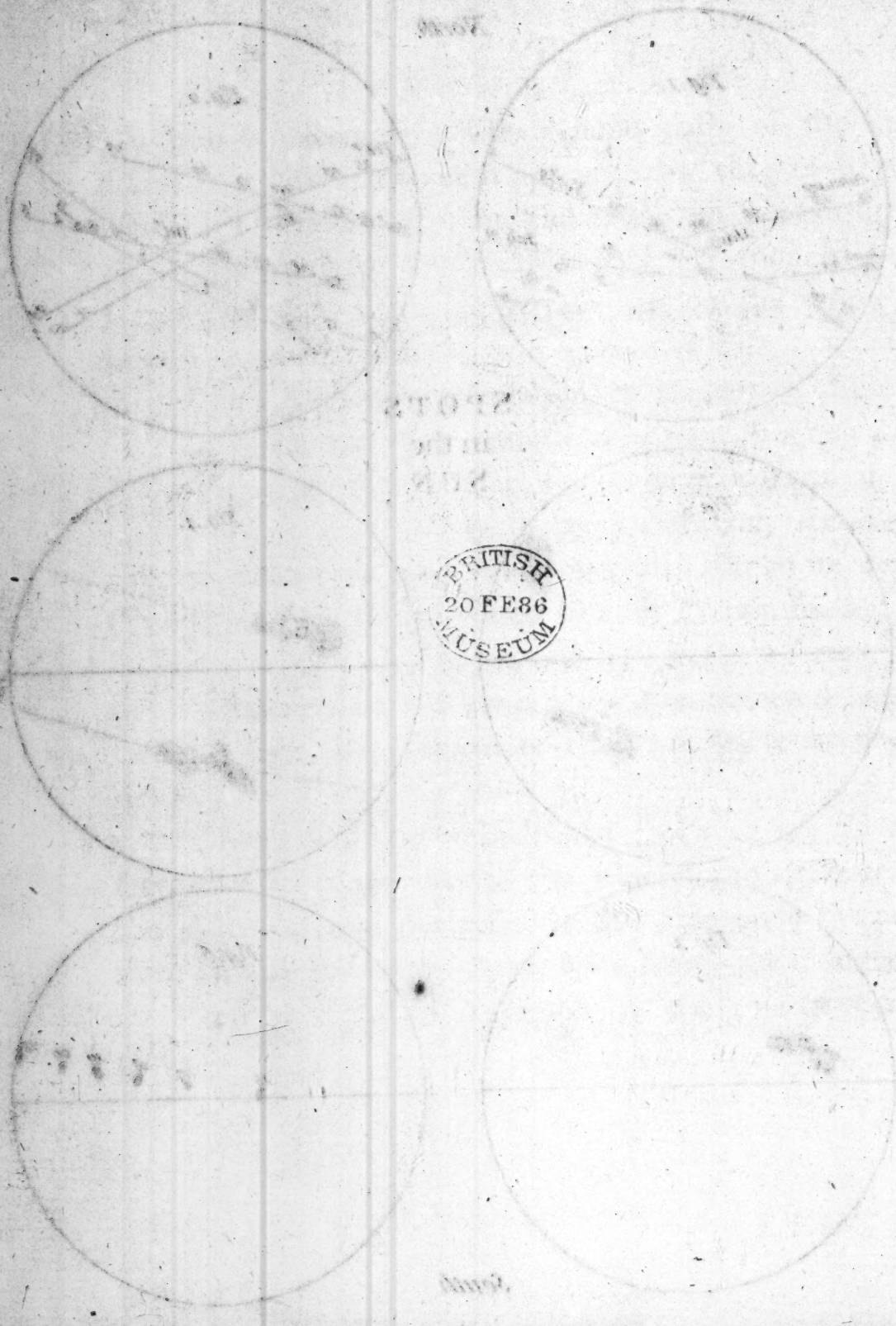


Fig. 6.



South



LECTURE III.

LADIES and GENTLEMEN,

I Am happy to reflect, that in your walk to this aſſembly this evening, you could not but obſerve ſomewhat of the advantage we derive from that fair planet which is the ſubject of our preſent diſcourſe: I need not relate to you the pleaſures of a moonlight walk, or remark the cool ſilvery beam and the ſober reſplendence, ſhed by our attendant ſatellite; yourſelves are witneſſes, that its ultimate degree of brightneſs is no ill ſubſtitute for the ſun himſelf, and that, after the ſultry heat of an autumnal day, we enjoy no leſs the riſing of the moon, than after the ſeaſon of repoſe, we enjoy the beams of morning.

Is it not laudable to inquire into the regulations, and the propertiesof this gentle planet? is it not natural to wiſh for information with regard to its changes, of which we are from time to time ſpectators? with regard to its influences, which cannot but be conſiderable? Such curioſity is highly honourable, and I hope in the courſe of this evening to enliven and gratify it.

You are ſenſible, that although at this time the lunar orb ſhines with full reſplendence, yet that it has not long done ſo, nor will long continue to do ſo, but "nightly changes in "her circling orb:" the reaſon of this variation of appearance will quickly engage our attention.

We might, to be ſure, take the moon as at this time, and by conſidering her relative ſituation to the ſun and earth, deſcribe the cauſes of her preſent plenitude; but, I think it will be more regular, previouſly to obſerve, that ſhe is at no very great DISTANCE from the earth (as diſtances are found among heavenly bodies), but is a cloſe attendant on our ſervice, and no further off than about ſixty ſemi-diameters of the earth, or 240,000 miles; and revolves round the earth from weſt to eaſt, in about twenty-ſeven days, which is called *a periodical month*. According to that part of the orbit of her revolution wherein ſhe is when we obſerve her, ſuch is the aſpect ſhe preſents to our view.

If the moon was a body poſſeſſing native light, we ſhould never perceive in her any diverſity of form; but as ſhe ſhines entirely by light received from the ſun, and reflected by her opacity, it follows, that according to the ſituation of the beholder with reſpect to her illuminated parts, he will behold more or leſs of her reflected beams: for only one half of a globe can be enlightened at one time.

The affair is rendered familiar by a ſimple experiment: I ſet this candle at the further end of the table; that lady will lend me her pin-cuſhion, I place it at ſome diſtance from the candle to repreſent the earth; and the moon is — my watch, if you pleaſe. Obſerve that I place the watch *between* the light and the pin-cuſhion (this is termed *conjunction*): the dial-plate is turned to the ſun, indicating a new moon, or, the moon in ſuch a ſituation that its enlightened parts are turned *from* the earth. I ſay the earth being unable to look through the body of this orb, can ſee no light whatever

whatever reflected from it; but as I move it a little to the left, the dial-plate comes in ſight; and the further I move it to the left (always preſerving its circular motion round the pin-cuſhion) the more of the dial-plate becomes viſible, till at length having got half through the revolution, the dial-plate is exactly oppoſite to our ſuppoſed earth, and viſible diſtinctly and entirely to the oppoſite part of it.

Obſerve, if you pleaſe, that when we ſet off, the earth and the moon were in a direct line with the ſun, the moon being *between* the other two; but now the moon and the earth are again in a direct line with the ſun, but the moon is *without* the other two, and the earth is *between*; (this is termed *oppoſition*:) thus, to-night (it being full moon) where are we to ſuppoſe the ſun, or in what quarter of the heavens ſhould we ſeek him?—Diametrically oppoſite to the moon. There remains now only to continue the courſe of the moon round the earth, to complete a revolution, and bring her again to the ſtation ſhe quitted.

This would be an exact repreſentation of theſe planets, were the earth always at reſt; but as, while the moon has been thus engaged in her courſe, the earth alſo, which has a courſe of her own, has minded her own buſineſs, and advanced during one lunar revolution (or month) in her proper orbit, ſhe lays the moon under the neceſſity of adding ſomewhat to her progreſs, in order to come again exactly into a direct line between the ſun and the earth, from which direct line ſhe is to begin her courſe anew. This additional time is upwards of two days, and five hours, making in the

the whole twenty-nine days, twelve hours, and forty-four minutes, which is termed a *ſynodical month*.

I believe, having got theſe bodies in a ſtraight line, I may as well explain the nature of ECLIPSES. I ſaid lately that the earth has a courſe of her own; ſhe being the primary planet, I muſt no doubt conſider her courſe as the original, and obſerve, that the line deſcribed by the moon in her revolution, does not always agree with the line of the earth's motion; it is not, I ſay, in the ſame plane, but is ſometimes higher, ſometimes lower; ſo that it agrees with it only now and then, but croſſes it in certain parts in moſt of its revolutions. You ſee therefore at once, that if it be *higher* than the plane of the earth's motion, when it is between that and the ſun, it cannot intercept the light of the ſun from the earth (which is what conſtitutes an eclipſe of the ſun); it cannot, I ſay, prevent the earth from ſeeing the ſun, for the earth ſees *under* it: or if, when between the ſun and the earth, it be *lower* than the plane of the earth's motion, it equally avoids hindering our ſight of the ſun, for the earth ſees *over* it: but when between the ſun and the earth, the moon moves in that part of her orbit which coincides with the plane of the terreſtrial motion, then ſhe is *bonâ fide* interpoſed between the ſun and the earth, and in conſequence, the beams of the ſun intended for the earth are received by the moon, and the earth is deprived of them. This conſtitutes a SOLAR *eclipſe*: in other words, the ſhadow of the moon falls upon the earth.

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An eclipſe of the moon, it is evident, cannot happen in this quarter, for ſhe has no light of which to be deprived, her unilluminated face being turned toward the earth; nor can it happen when ſhe has performed a quarter of her courſe, for then ſhe is not in a direct line with the ſun and the earth; we muſt look for it therefore at the full, for there only ſhe is liable to this event.

As the path of the moon is not always coincident with the orbit of the earth, ſhe enjoys at this period much the ſame advantages as the earth was before obſerved to do; I mean, that when her courſe is *higher* than the earth's, ſhe ſees the ſun by looking *over* the earth; and when her courſe is *lower* than the earth's, ſhe ſees the ſun by looking *under* it: but when they coincide, the earth intercepts the light of the ſun, and deprives her of thoſe beams intended for her uſe; in conſequence, having no light in herſelf, ſhe reſumes her natural darkneſs, and ceaſes to ſhine, in ſuch proportion, as the earth intercepts her light; or, in other words, as the ſhadow of the earth falls upon her.

Theſe, LADIES and GENTLEMEN, are the elements and principles of that *phænomenon*, which excites in the mind of ignorance ſuch dread and terror, which has ever been regarded as an evil omen, has ſunk the hearts of the moſt valiant, and weakened the ſpirits of the moſt magnanimous; yet nevertheleſs has ſometimes produced the happieſt effects; witneſs the celebrated eclipſe of the ſun, foretold in the infancy of aſtronomy by THALES the Ionian (*ante* A. D. 603), which happening during a battle between the armies

of Alyattes king of Lydia, and Cyaxares the Median, was regarded by both parties as an evil omen, ſuſpended the engagement, and concluded a peace.

Such a phænomenon, once generally dreaded, and dreaded ſtill among the unenlightened nations of the earth, will this evening yield us rational entertainment; ſuch is the difference between knowledge and ignorance, *we* look out for an eclipſe, and anticipate the ſatisfaction, while the ſavage ſhrinks from the awful ſight, or clatters every inſtrument capable of noiſe, that he may awaken the moon from her ſwooning, or eaſe her in her labour. The heathens of antiquity uſed to light up torches, to blow trumpets and horns, to rattle their veſſels of braſs and iron; and after the eclipſe was over, proceſſions and ſacrifices expreſſed their joy at her deliverance. Our compaſſion withholds the ſarcaſm; "Lo! "theſe are the gods you worſhip;" while we cannot but regret the blindneſs of mankind, who adopted ſuch impotent divinities, who after being ſpectators of the entire paſſiveneſs, and utter inactivity of their ſuppoſed deities, yet called for help on gods unable to help themſelves, and ſought protection from gods on whom they alſo beſtowed aſſiſtance.

The advantages we enjoy in the ſcience of the preſent day, may profitably engage your reflection while attending to an example of ſuch a phænomenon; the moon now ſhines full; but obſerve, on her eaſtern limb there ſeems a ſlight deficiency of light; now it augments into a notch of dark; now the dark increaſes; ſhe advances, you ſee, into the ſhadow of the earth, which now covers great part of her, now gradually withdraws

withdraws to the other ſide of the moon, now is ſcarce apparent even there, and now, having quitted the ſhadow, the moon again ſhines with her former luſtre.

Such, LADIES and GENTLEMEN, is the courſe of eclipſes: they are greater or leſs, according as the moon enters more or leſs deeply into the ſhadow of the earth, and its atmoſphere, which, in current language, may paſs for one uniform ſhadow. The time of the longeſt poſſible duration of a total lunar eclipſe, is three hours, fifty-ſeven minutes; but a total lunar eclipſe may be twenty minutes ſhorter. The longeſt time of a total eclipſe of the ſun (*i. e.* of total darkneſs) is about four minutes; and the time taken by the moon to croſs the ſun's body (*i. e.* the duration of the eclipſe), is, at her neareſt acceſs to the earth, about two hours and three quarters.

The moon ſometimes in the middle of a total eclipſe is viſible in ſome places, and inviſible in others, according to the different conſtitution of the air; but generally appears of a duſky, reddiſh, or copper-colour, eſpecially towards the edges: this colour is owing to the ſolar rays refracted through the earth's atmoſphere, and reaching the moon; the red rays being leaſt refracted, they paſs through our atmoſphere in the greateſt quantity.

We noticed, when ſpeaking of the ſun, that although he is a globe, yet by reaſon of his diſtance he appears *flat*; and the ſame we obſerve of the moon; which, though unqueſtionably a globe, yet preſents a *flat* face (termed a Diſk) to the ſpectator. The SURFACE of this face, even to the naked eye, appears rough, uneven, and replete with mountains and

caverns; and through a teleſcope we obſerve very plainly the ſeparation between her enlightened and her dark parts, is broken by hills and valleys; in her lately enlightened parts, preſenting many dark ſpots, while in her unenlightened parts, the tops of the mountains and eminences catch the firſt gleams of the ſolar rays, and are diſtinctly ſeen to enlarge, and become brighter as the light riſes and ſpreads upon them. This very agreeable ſight requires but an hour or two to complete it.

The mountains in the moon are thought to be higher than any we have on earth, and her caverns proportionally deep; which has given occaſion to ſome, to ſuggeſt that if ſhe has any inhabitants, they may uſe them as cool retreats from the ardour of the ſun, which cannot but be very great in the courſe of a day ſo long as a fortnight is with us. For you will pleaſe to obſerve, that during the courſe of the moon round the earth, the ſun enlightens ſucceſſively every part of that globe; but only *once*; ſo that ſhe has but one day in all that time: ſhe revolving on her axis only once, conſequently only once turning in ſucceſſion each part of her orb to the ſun. Obſerve too, that as ſhe turns on her axis in the ſame time as ſhe goes round our earth, the ſame part of her body is directed towards us, and we ſee conſtantly the ſame aſpect; except what little variation is occaſioned by the different courſes of the two planets. To explain which, if we compare the face of the moon to a human face, we may ſay, that we ſometimes ſee leſs of her right cheek, and more of her left; ſometimes more of her right cheek, and leſs of her left; ſometimes

times we ſee as it were a little over her, and conſequently more of her forehead; ſometimes as it were a little under her, andconſequently more of her chin. This is termed her *libration*.

Since the moon's ſurface is ſo full of mountains, it has been aſked, why we do not ſee them project like ſo many teeth of a wheel on the bright edge of her diſk. The anſwer is, that if one row of mountains only occupied that ſtation, poſſibly we might diſcern them; but, ſince behind theſe there are others, *they* fill up the interval between mountain and mountain, ſo that the whole appears level: much like the waves of the ſea, which, though really elevated and depreſſed, yet form an even line upon the horizon.

We remark here, that this roughneſs of ſurface is of great uſe to us: for an opaque body perfectly ſmooth and regular, is by no means well adapted to reflect light in a conſiderable quantity, but merely would gliſten in a particular part of its ſurface, and the rays from the other parts would ſo ſtrongly diverge as to be loſt, and never reach any ſpectator: whereas by a rough ſurface, the rays of light are refracted innumerable ways, and fall upon innumerable points, which reflect them copiouſly in every direction.

In the moon, ſome parts are better fitted to reflect light than others; the dark parts have been thought by ſome to be ſeas and lakes; and it has been obſerved, that the line between the dark and light parts, is in theſe places ſmoother than elſewhere; while others ſay, they diſcover even in the darkeſt parts of the moon, caverns and empty pits; theſe however *may be* ſhallows and rocks; or caverns in ſhallows and rocks.

In the enlightened parts of the moon, are diſcernible darkiſh ſpots, which can be no other than cavities; for the ſhadows are obſerved to fall different ways, according to the ſituation of the ſun, and when his beams fall *directly* down them, they have no ſhadow.

It has been debated whether the moon poſſeſſes an ATMOSPHERE: if ſhe does, it is much thinner and more rarefied than our air is, for it has no perceptible effect on the light of the ſtars, when approached by the body of the moon, but inſtead of being obſcured, or in anywiſe dimmed by it, they preſerve their brightneſs even in actual contact. On the other hand, in certain total eclipſes of the ſun, a faint pale light has been ſeen environing the moon, which is beſt accounted for on the ſuppoſition of an atmoſphere.

I proceed to ſuggeſt a hint or two on the PECULIARITIES *apparent to the inhabitants* (if there are any) of this planet, ſince in many reſpects they totally differ from our obſervations and inſpections of the moon.

(1.) As the moon ſhews conſtantly (or nearly) the ſame ſide to the earth, thoſe inhabitants *only* who reſide on this part of the moon, will ever have a view of the earth; and if thoſe on the other ſide have curioſity enough to deſire the ſight, they muſt take a journey on purpoſe. (2.) To thoſe who are in conſtant view of the earth, it appears fixed, or at leaſt to have no circular motion; or but little, according to the moon's libration. (3.) To thoſe who reſide in the centre of the moon's viſible hemiſphere, the earth ſeems *vertical*, and directly over their heads; as the ſun appears at noon to

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our torrid zone. Whereas, (4.) to thoſe who live in the extremity of that hemiſphere, the earth ſeems ſtationed in their horizon; and as they move round the earth (monthly), the earth ſeems to circulate round them, as the ſun ſeems to us to move round the earth. (5.) The earth to the lunarians, has in the courſe of a month the ſame variety of phaſes as the moon has to us; when the moon is at full to us, the earth being between that and the ſun, its enlightened parts are turned *from* the moon; it is therefore *new*. As the moon gets toward the ſun, and between the earth and ſun, the enlightened parts of the earth become gradually viſible to the moon, and at new moon, it is to them *full earth*; they beholding the whole enlightened terreſtrial hemiſphere. The light thrown upon the moon by the earth is not viſible to us at new moon, becauſe the very greatly ſuperior reſplendence of the ſun overwhelms the effect of that re-reflection which would render the moon viſible, but it appears a few days before, and after the new moon, rendering viſible the whole of that planet, even its (otherwiſe) unenlightened and dark parts. (6.) The earth appears to them variegated and ſpotted, by means of its continents, iſlands, oceans, &c. By theſe ſpots the lunarians will determine the earth's diurnal rotation, as we do that of the ſun. (7.) During an eclipſe of the ſun (from us), they will ſee the ſhadow of the moon depriving the earth of part of its light, and progreſſively moving over it in a certain direction; but will never ſee the earth totally eclipſed, becauſe the moon's ſhadow is broad enough to cover only a ſmall part of it; but the ſun may be totally eclipſed from

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them for a time, by their immerſion in the ſhadow of the earth.

Having by this time acquired a pretty good idea of the nature of the lunar phaſes, of the ſhare of that planet in eclipſes, of the external ſtructure of her orb, and of other peculiarities, it remains to inquire into ſome of thoſe benefits we receive from this attendant.

I need not remind you, that as the ſun riſes he alſo ſets; that as he viſits us by day, he withdraws by night; that his abſence is the cauſe of darkneſs; that darkneſs is unſociable, and gloomy, I might almoſt ſay hideous; ſurely then, we muſt acknowledge our obligations to the ſilver moon, for acting as deputy in the abſence of the ſun; this prolongs the day, ſometimes almoſt doubles it, and though in itſelf an opaque and ſmall body, being but 2184 miles in diameter, yet by its proximity, it affords us more light than all the ſtars put together, though probably they are globes of fire; it is true this magnificent reflector is perpetually changing; and her orbit heightens, or lowers, in ſeeming irregularity; but this irregularity is beneficial; it is limited ſo as never to be injurious; and by it the moon avoids a conſtant return of *exact* oppoſition and conjunction.

The influence of the moon on the tides (to be explained elſewhere) is well known; by the variations of her orbit they aſſemble, as it were, in different places, and inſtead of exerting their force conſtantly againſt the ſame ſpot, it is directed, now here, now there, ſo that the ſhores are but ſeldom oppreſſed by its ſtrongeſt effort, and in conſequence leſs ſubject

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to damage. Need I remind you that this planet ſometimes prolongs the evening of the day, ſometimes anticipates the rays of the morning? how thankful the benighted traveller for the firſt, how joyful the almoſt embayed ſailor for the latter? or, when ſhe ſhines throughout the night, we wonder not that where the ſultry ſun has ſcorched the inhabitants by day, they rejoice in the cool moon-light, as in a ſeaſon of refreſhment. The Arab now prolongs his journey, and the camel enjoys the ſalutary breeze; the very ſands, burning but a few hours ago, now become bearable, and ſeem ſenſible of their deliverance from the ſolar fire.

Why is the light of the moon cool? why is it not ſultry as that of the ſun? (1) Becauſe it poſſeſſes not power ſufficient to agitate our atmoſphere, and is deficient in velocity to make ſufficiently active rebounds in every direction, from every quarter where it ſtrikes, having previouſly undergone ſuch refractions and reflections in the lunar orb; like a rebounding ball, it has loſt great part of that vigour with which it ſtruck its immediate object. (2) Becauſe the globular form of the moon *diverges* its rays, ſo that they widen and ſpread every way, conſequently a ſmaller number falls on any given ſpace; and this weakens the lunar rays ſo greatly, that perhaps at no very extenſive diſtance beyond the earth, ſhe may be ſcarce viſible. This is certain—that all the burning-glaſſes (which, by condenſing the ſun's rays ſome thouſand times, produce ſurpriſing heat) are unable, by any condenſation of the lunar rays, to unite them into heat, ſenſible either to the hand, or to the thermometer.

Should any aſk, why ſhines not the Moon conſtantly during the night, and conſtantly during the month? I reply, night is the ſeaſon for repoſe: of what benefit then were a perpetual moon? I reply, that the moon is not conſtant during the month to any one place, becauſe other places want her; and let not us, in this temperate latitude, wiſh to deprive of their luminary, thoſe obliged to travel and work by moon-light; or render more hideous a polar winter, by withdrawing the company of the lunar orb.

But why ſhould the moon perpetually change? Becauſe without ſuch change ſhe could never have fulfilled her appointment, of indicating times and ſeaſons (rural, and civil, perhaps ſacred) to mankind, which is evidently her very important charge.

"The firſt men, affected by the conſideration of the twofold ſervice the moon did them, by enlightening the night, and by regulating all mankind, conſecrated the uſe they made of its phaſes by a holiday or feaſt, which they ſolemnized at every time of its renewal. The *Neomenia* ſerved in a plain and commodious manner to regulate the public exerciſe of their devotion. But if they regularly gathered together to make their ſacrifices, and lovingly to viſit each other at the return of every new moon, that worſhip and thoſe holidays were no way relative to the moon itſelf. God was the object of them; and the moon had no other ſhare therein, but that of putting men in mind of celebrating them.

"The ſtars had not as yet received the names they now go by. Without taking notice of the ſeveral conſtellations under which the moon is ſucceſſively placed within the ſpace of its monthly courſe,

courſe, men were contented with only determining its progreſs, by the variety of its appearances; and inſtead of employing calculations, as has been ſince done, to mark out the preciſe inſtant of its having overtaken the ſun anew, under which it had paſſed nine and twenty days before; the aſtronomy of thoſe times was contented with the bare teſtimony of the eyes, and they reckoned the new moon from the day it could be perceived. It was in order to get intelligence of it, without hindrance, that they aſſembled and met together in high places, or in deſarts remote from the habitations of men; that no obſtacle or any thing might ſcreen the horizon from them. When the creſcent had once been ſeen, they ſolemnized the Neomenia, or the ſacrifice of the new moon, which was ſucceeded by a repaſt, where all the families cheerfully, and with ſimplicity and candour, eat what had been offered to God, and conſecrated by prayer. When any notable event occaſioned the inſtitution of ſome annual feaſt, they very often joined it to the Neomenia, which was the uſual day of aſſembly. The new moons, which concurred with the renewal of ſeaſons, and to which our four Ember-weeks do ſtill correſpond, were the moſt ſolemn of all. That cuſtom of meeting together in high places or in deſarts, that of keeping the new phaſes, that of celebrating the Neomenia by a ſacrifice and by prayers, in particular, the ſolemnity of the new moon, which concurred with the ſowing, or followed the intire gathering of the fruits of the earth; finally, the repaſt and the ſongs which came after the ſacrifice, are uſes, all of which were, from this common ſource of mankind, handed down to all the nations of the univerſe. All theſe cuſtoms we find again among the Hebrews, the Egyptians, and the Arabians, from whom they, together

gether with Mahometiſm, were delivered down to the Perſians and the Turks. The ſame uſages were common to the Greeks and the Romans, as alſo to the Gauls, and to nations which had no manner of communication with each other: They were found again amongſt the Caribbees, and ſome other American nations.'

" Scripture abounds with facts, which evidently prove that the cuſtom of ſacrificing on high places was eſtabliſhed among the Hebrews as well as the other nations, even before the law, and that it even ſubſiſted in Iſrael ſince, and in ſpite of the law.

" If the Hebrews and the Heathens agree together in the practice of their ſacrifices, purifications and libations, in their inclination to gather together upon high places, and in the regularity of their Neomeniæ, a grain of ſincerity will make us ſenſible, that the Hebrews are not indebted to the Heathens for theſe cuſtoms, and that the Heathens did not borrow them from the Hebrews; but that both the Hebrews and the Heathens had them from the remoteſt antiquity, and from the common ſource whence they all ſprung, I mean from the family of Noah, when the whole was contained in the plains of Chaldea. This point of reunion, equally plain and certain, is the ſole unravelling of the difficulties which have divided the learned. The whole of mankind being gathered round Babel, had already the practice of the ſacrifices made before, and renewed by Noah immediately after the flood. For want of writing, what means could be more natural and more public, to call together to the ſacrifice a multitude of families diſperſed, than the ſight of the decline of the moon, and the return of the new? It is even very likely, that the ſun, which before the flood marked the courſe and the bounds

of the year, by the diverſity of the ſtars under which he paſſed, did it however, without leaving the Æquator, and put no difference between one day and another day, or one ſeaſon and another. The moon was then the moſt proper means to mark out the beginning and the progreſs of months: and Noah, when he fixed the religious meetings at the time of the Neomenia, did but renew what was practiſed before the flood. So the fathers of all nations having been long enough under the ſame leader, in the ſame place, united by the ſame wants, the ſame language, and the ſame practices; it is the plaineſt thing in the world to think that the cuſtom of meeting in high places, and at the return of the new moon, the offering of the fruits of the earth, the ſacrifices, the common repaſts and the ſongs, are all uſages which have with them paſſed through all the earth. This is what they have conſtantly preſerved ever ſince their diſperſion; and in every other thing, they conſtantly proceed with making themſelves diſtinguiſhed from each other. You are ſenſible, how this agreement of all nations in the religious cuſtoms, which ſuited the firſt ages, and their infinite variations in all the reſt, concur to teſtify the truth of Moſes's narration, and the perfect knowledge he had of the origin of things."

Theſe are the ſentiments of a very agreeable author. Will you not, LADIES and GENTLEMEN, unite with me in regretting that mankind did not preſerve pure the memorial of times and ſeaſons, but that unfortunately, and impiouſly, they looked not beyond the inferior occaſion of their aſſembly, and took this *occaſion* for the *object* of their worſhip. I need not here repeat to you, the coſtly ſacrifices, the pompous offerings, the ſolemn proceſſions,

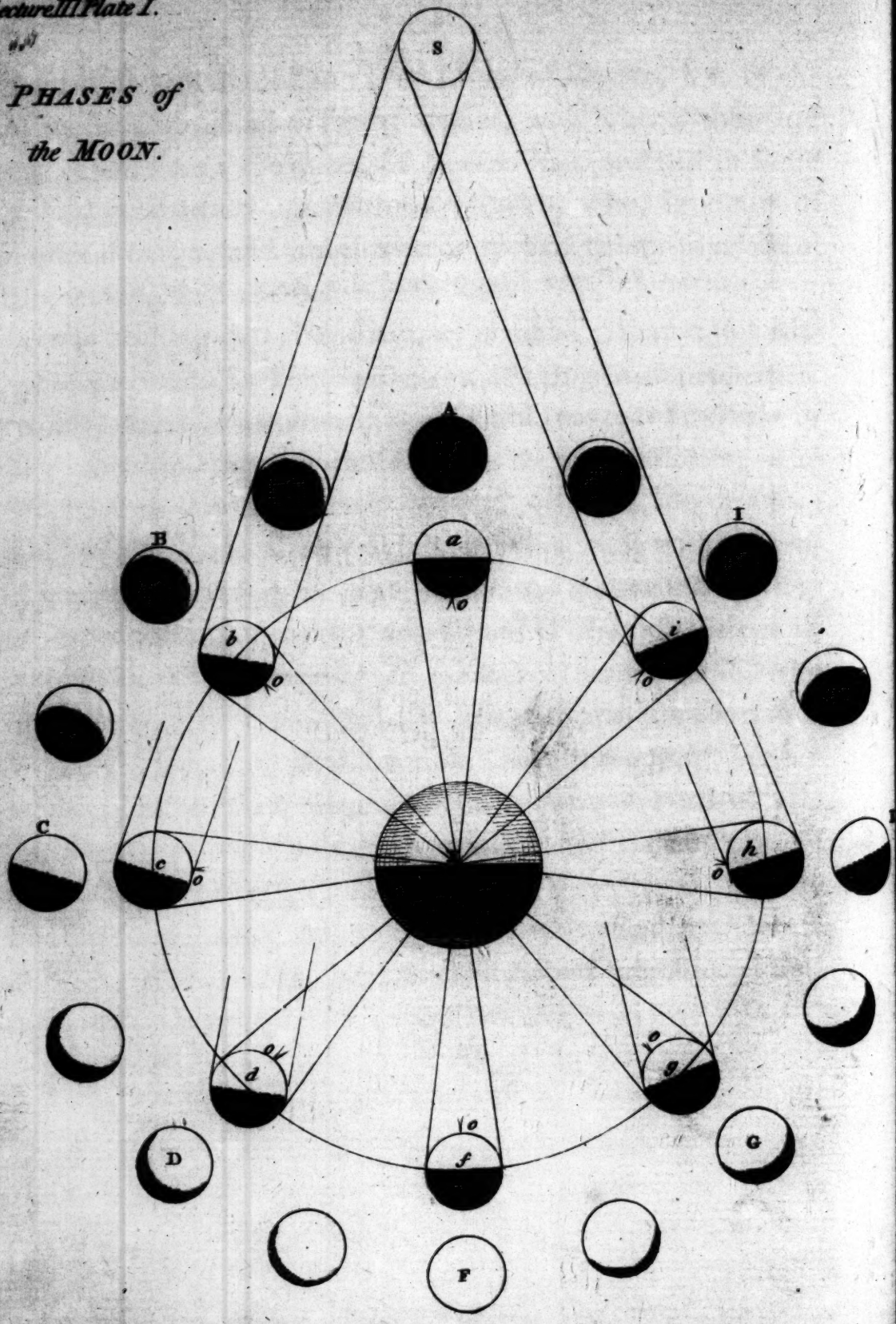
proceſſions, in honour of Diana, of Luna, of Hecate, i. e. of the moon, under a thouſand different names, and with a thouſand different ceremonies: the queen of heaven had (and ſtill in ſome places has) numerous ſuperſtitious votaries, who, ignorant of philoſophical truths, and uninſtructed by benevolent revelation, practiſed abſurdities, and believed in lies.

There is nothing more important to mankind, than a juſt eſtimate of occurrences and circumſtances, of things and properties. Ungrateful! thoſe who continue inſenſible to the kindneſs of Providence, in appointing various planets to various duties; who will not ſee their order, their beauty, or their importance; but without thankfulneſs enjoy their benefits, and without gratitude receive their ſervices; who repine at that economy they cannot improve, and deny the excellence of the diſpoſitions of ſupreme Wiſdom. Unhappy! on the other hand, thoſe who overvalue ſecondary cauſes, who miſtake ſervants for ſuperiors, who cry to the ſun, "O Baal, hear us!" to the moon, "We beſeech thine influence!" Unhappy! who rely on created objects for protection, and expect ſuccours even from a radiant planet! It becomes us to remember, that from ſuch ſuperſtition we are happily liberated; may we never be enthralled by ſimilar bondage, or be captivated by the ſubjects of viciſſitude and mutability!

OBSER-

Lecture III Plate I.

PHASES of the MOON.



OBSERVATIONS on the PLATES

Belonging to LECTURE III.

PLATE I. exhibits the PHASES of the MOON, ſhewn to the earth during one rotation. The true diſtances of the heavenly bodies from each other, are by far too immenſe to be regarded in theſe kind of explanatory figures; for it is evident, that were S (the ſun) any thing like an adequate proportion to E (the earth) in ſize (or in diſtance), the earth, &c. muſt have been almoſt inviſible by its ſmallneſs, or the ſun have been very far beyond the limits of the plate.

In this example the earth (E) is ſuppoſed at reſt, while the moon circulates around it, according to the order of the letters. The eight ſmaller letters, *abcdfghi*, ſhew the relative ſituations of the moon to the earth during her courſe; the larger letters, ABCDFGHI, ſhew what proportion of the moon is ſeen *enlightened* by us, when we ſurvey her from the earth. We obſerve, that the light begins by a ſlender ſtreak on the right hand (or weſtern limb), which increaſes to half (at C), and to the full moon (at F); from whence it decreaſes, and takes the left ſide of the moon (or eaſtern limb), till it again becomes a ſlender ſtreak, as at I.

It appears by fixing on any one part of the moon's ſurface, as at *o*, that during her whole revolution ſhe turns but *once* on her axis—that ſhe has but one day, and one night: as at *a*, *o* is midnight; *b*, *o* advances toward day-break; *c*, *o* is early morning; *f*, *o* high *noon*; *h*, *o* afternoon; *i*, *o* night. It appears alſo, that the ſame part of the moon is conſtantly directed toward the earth; as is clear by tracing the marks at the letters *o o*, *&c.*

PLATE II.

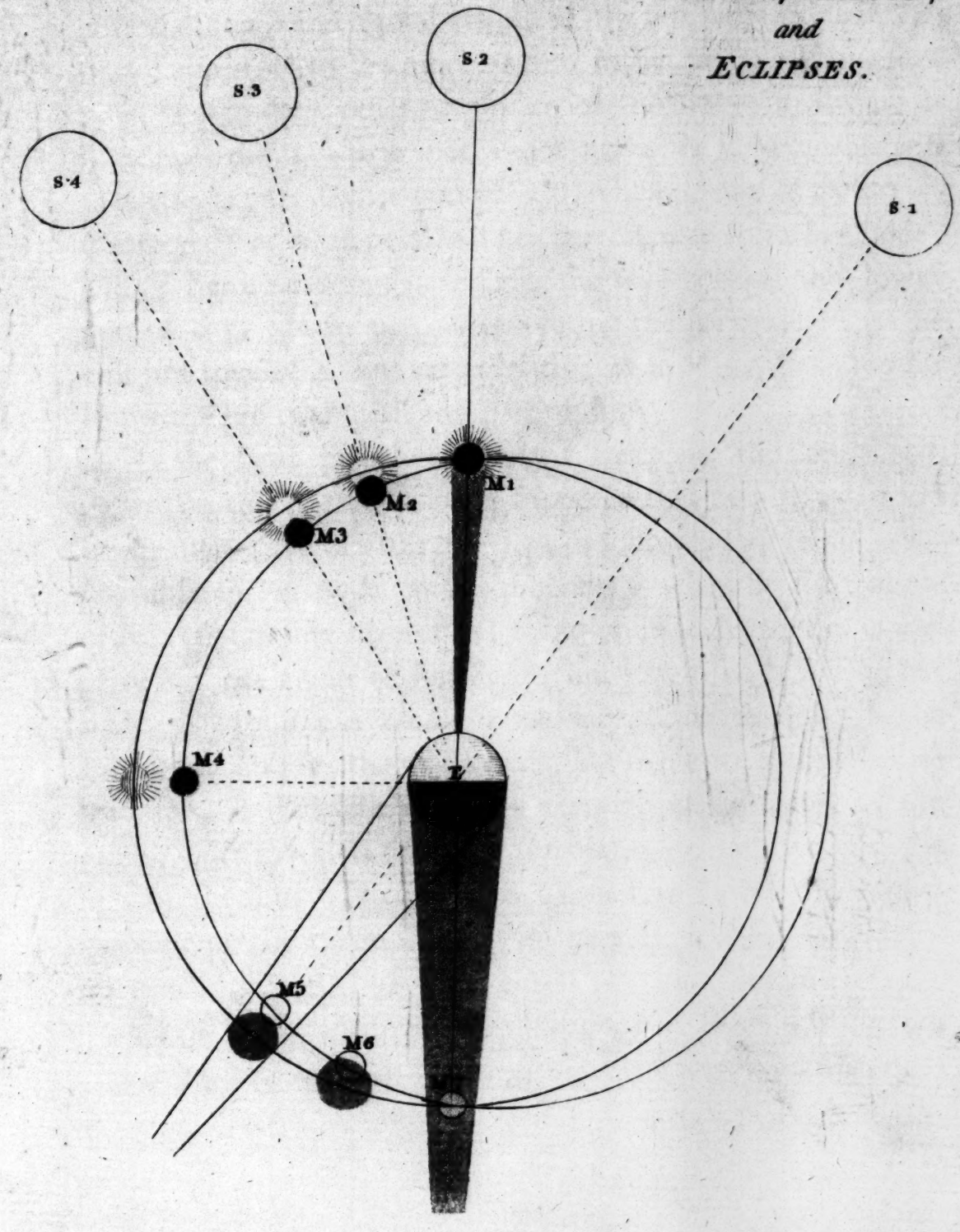
It has been obſerved in the Lectures, that whatever may be the true ſtation of heavenly bodies, the eye eſtimates them as at one uniform diſtance; ſo that however remote may be really S 1, S 2, S 3, S 4 (the ſun), yet it appears as if cloſe to the moon: its ſtation is therefore in this example tranſpoſed, and its courſe is *ſuppoſed* to be round the earth (E), which is *conſidered* as at reſt. In this caſe, we note firſt, that the *apparent* orbits of the ſun, and that of the moon, (M 1, M 2, &c.) are not of equal height, but M 1, M 2, &c. is ſuppoſed to be in one part of its courſe below, and in the oppoſite part of its courſe above that of the ſun, and only to coincide with it in two parts, M 1 and M 7, which are termed NODES. This principle is illuſtrated by two hoops of equal ſize, one put within the other, and ſomewhat lowered at one part; the oppoſite part *will* be heightened, and it will touch that hoop which ſurrounds it, *only* in two oppoſite parts, where it may be ſaid to form a knot, or node; one of which may very aptly be called, in reference to the courſe of ſuch a hoop, deſcending, the other aſcending. Vide Lecture, page 38.

This premiſed, we obſerve, that there being no intercepting body between S 1 and E, E enjoys the whole of the light coming from S 1; but between S 2 and E, the nodes of the lunar courſe happening to fall, ſo ſoon as M 1 is arrived at its node it begins to intercept the light (and to conceal part of the body) of S 2 from E, and this it continues to do during ſo long time as S 2, M 1, and E are in a *perfectly* ſtraight line.

This

Lecture III Plate II.

ORBIT of the MOON, and ECLIPSES.



This event, as has been noticed in the Lecture, can only happen at new moon; and a total eclipſe of the ſun, it is evident, can only happen when the moon is new in her node. If we ſuppoſe, that in ſome other revolution of the moon, ſhe is new at ſome little diſtance from her exact node, as at M 2, ſhe will then eclipſe only ſuch a part of S 3 (whoſe place as before is tranſpoſed) as is proportionate to her diſtance from her node; alſo, if her courſe be deſcending, ſhe will conceal the lower part of S 3. If in another revolution ſhe is new at M 3, ſhe will juſt touch S 4, but very ſlightly; as at M 4, ſhe is too far below the ſun to conceal any part of him.

Preciſely the ſame principles apply to explain the remaining figures on this plate. It being ſuppoſed that in one revolution of the moon, ſhe is FULL at M 5; it follows, that ſhe is ſo far diſtant from her node, as to be barely touched by the ſhadow of E. In another revolution, being full at M 6, ſhe is deprived of great part of her light; but when ſhe is full in her node, at M 7, ſhe is totally immerſed in the ſhadow of the earth, not only in the exact node, but for ſo long time before and after, as ſhe takes in paſſing through the ſhadow of the earth; during which time the lunarians are deprived of the light of the ſun. Theſe eclipſes happening during the *aſcending* node of the moon, her *upper* part is eclipſed in conſequence.

On theſe plates the ſhadows are diſtinguiſhed from the objects, by being engraved in ſtippling, for the ſake of perſpicuity.

PLATE

PLATE III.

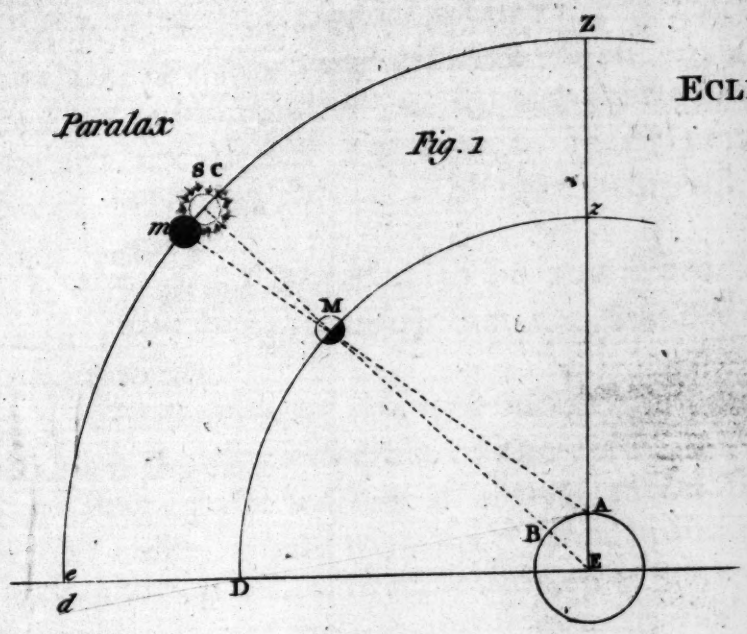
Fig. 1. PARALLAX.—There is ſcarce any perſon who has not obſerved, that by looking at an object, firſt with one eye only, then ſhutting that, and looking at the ſame object with his other eye, the apparent place of that object is changed with regard to others immediately behind it; and this is more notorious, when the object itſelf is near, and its back-ground diſtant. Much the ſame is the effect of parallax with regard to the ſun, planets, &c. but more eſpecially with regard to the moon, ſhe being ſo near to us. If the earth were tranſparent, and a ſpectator ſuppoſed at E, he would ſee D and *e* in the ſame line, forming but one object; or, if he looked towards M, he would ſee M and S forming but one object; or if he looked perpendicularly, z and Z would form but one object. But on the ſurface of the earth, this would take place only in certain parts; *i. e.* where a ſtraight line drawn from the object would reach E. For example; to A, z and Z, are in the ſame ſtation, but when A looks toward M, it does not correſpond with the ſtation of S, but is ſeen *adjoining* to it at *m*: this effect is yet greater in the horizon, where D is not ſeen by A at *e*, but at *d*. So that, while to B the object M covers the object S, A will perceive no ſuch event. The application of this to eclipſes is evident, for if S be ſuppoſed a luminary, and M opaque, it will follow, that S will be eclipſed to B, but not to A.—Parallax at the horizon *lowers* an object one degree of the circle, as from *e* to *d*; but continually decreaſes its effect in advancing toward the zenith, ſo that it is barely half a degree at B, and at A nothing.

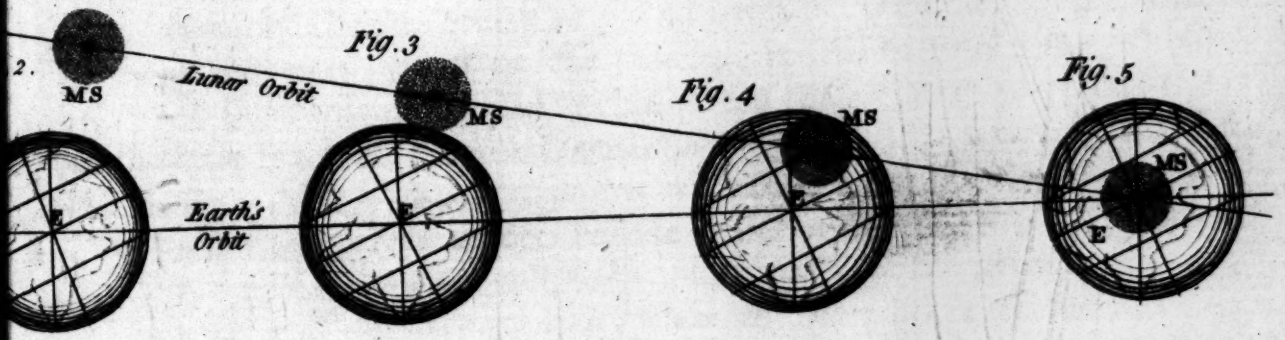
Fig. 2.

ECLIPSES

Paralax

Fig. 1





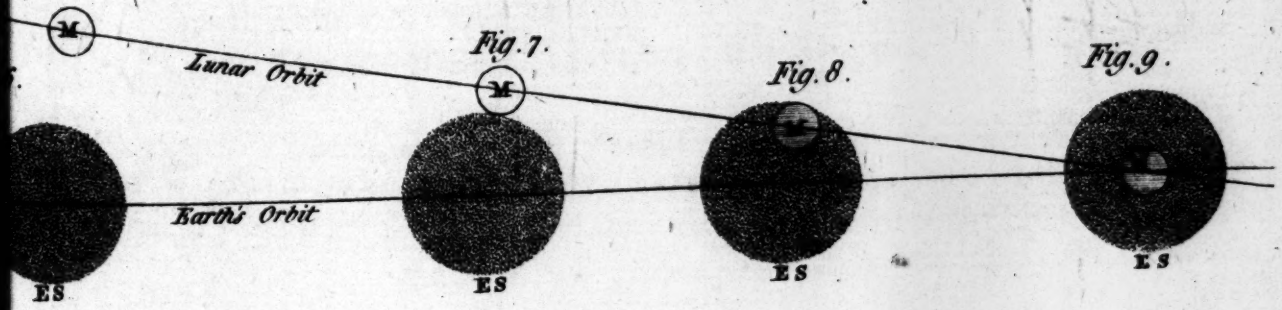


Fig. 2. 3. 4. 5. Shew more at large the inſtances in plate II. and repreſent ſo many revolutions of the moon, on the ſame ſcale: they are to be regarded as ſo many PLANS of the paſſage of the ſhadow of the moon at ſo many new moons. E the Earth, M S the Moon's Shadow, throughout the whole of theſe figures.

Fig. 2. The moon ſuppoſed to be new; but ſo high above the earth (ſeen from the ſun) that her ſhadow paſſes over it at ſome diſtance.

Fig. 3. The ſhadow of the new moon, ſuppoſed to fall ſo as juſt to touch the circumference of the earth, making no eclipſe.

Fig. 4. Plan of the ſhadow of a new moon falling completely on the earth, where we obſerve, that in ſome places the eclipſe will continue a conſiderable time, *i. e.* where the ſhadow is broadeſt; but at the top and bottom of the ſhadow it will be ſcarcely viſible, ere it be paſſed over. We obſerve alſo, that in the very centre of the ſhadow, it will be total; the whole of the ſun's body being hid from a ſpectator placed in the little black ſpot, which correſponds with AB, fig. 1. plate IV.

In fig. 5. the node correſponds with the centre of the earth. It will therefore be a total eclipſe at the equator, where the ſun is vertical, but no eclipſe in many parts of the globe.

Fig. 6. 7. 8. 9. Are ſo many plans of the paſſage of the earth's ſhadow at the time of full moon. M the Moon, E S the Earth's Shadow.

Fig. 6. The moon ſo high above the earth's ſhadow at the full, as to paſs at a diſtance above it.

Fig. 7. The moon at full juſt touching the earth's ſhadow:—no eclipſe.

Fig. 8. The moon at full, nearer to her node, totally eclipſed; but the upper part of her only for a very little time.

Fig. 9. Full moon at the node: therefore a total eclipſe of ſo long duration, as the moon is paſſing through the ſhadow of the earth.

PLATE

PLATE IV.

Fig. 1. ELEVATION of an eclipſe of the ſun. S the Sun, M the Moon, E the Earth. Here we obſerve, that the ſun being immenſely larger than the moon, occaſions *two* kinds of ſhadow from the moon: one a real and total privation of light; at the moon itſelf, of equal breadth with its diameter, *a b*, but decreaſing at a diſtance from the moon; and ere it reaches E, very much narrowed, as at AB. The ſecond kind of ſhadow is merely a partial privation of light; for M being ſo much ſmaller than S, can only conceal part of S, conſequently the other parts of S continue ſtill to impart light: this is termed a *penumbra*. It is evident, that wherever the total ſhadow AB takes its courſe, there is a total eclipſe. This anſwers to the black ſpot in fig. 4. 5. plate III.

Fig. 2. ELEVATION of the ſhadow of the earth during an eclipſe of the moon. We may obſerve, not only that the ſhadow narrows at a diſtance from E, but alſo, that much of the ſhadow which actually reaches *d e* (the moon's courſe), is that of the atmoſphere round E, which extends to *c*, while the ſhadow of E terminates at C; the diameter AB is augmented by the atmoſphere to *ab*, whereby the ſhadow is enlarged; but on the other hand, the refractive power of the earth's atmoſphere is ſo great, and it inflects the rays of the ſun ſo ſtrongly into itſelf, that the *pure* ſhadow of the earth extends leſs than 40 ſemidiameters of the earth; conſequently it is greatly attenuated before it reaches the moon, and has many of the ſolar rays intermingled with it. More than half of E is enlightened, AB being much below the centre E.

Lecture III.
Pl. IV.

ECLIPSES

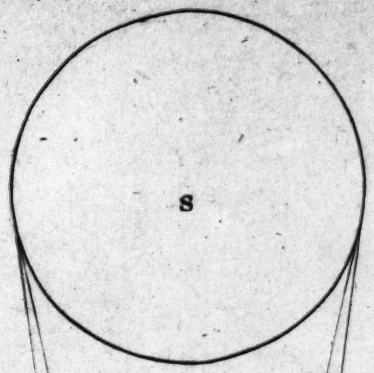


Fig. 1.

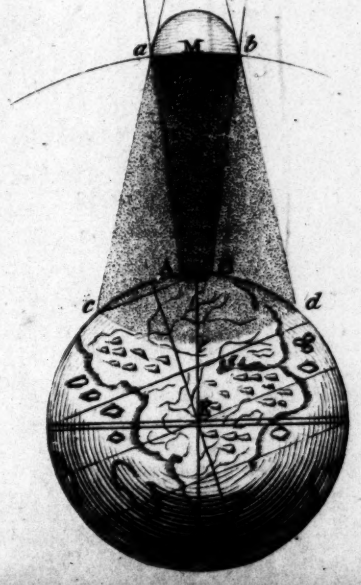
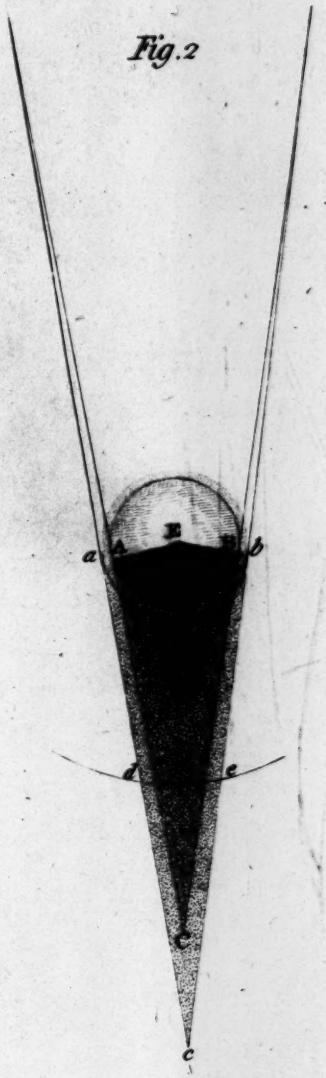
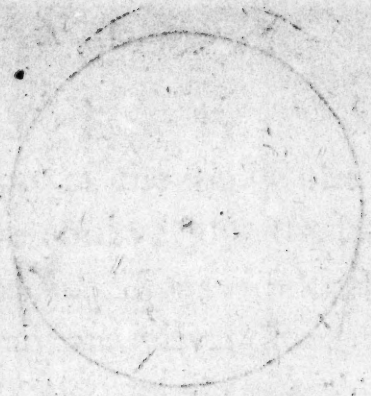


Fig. 2





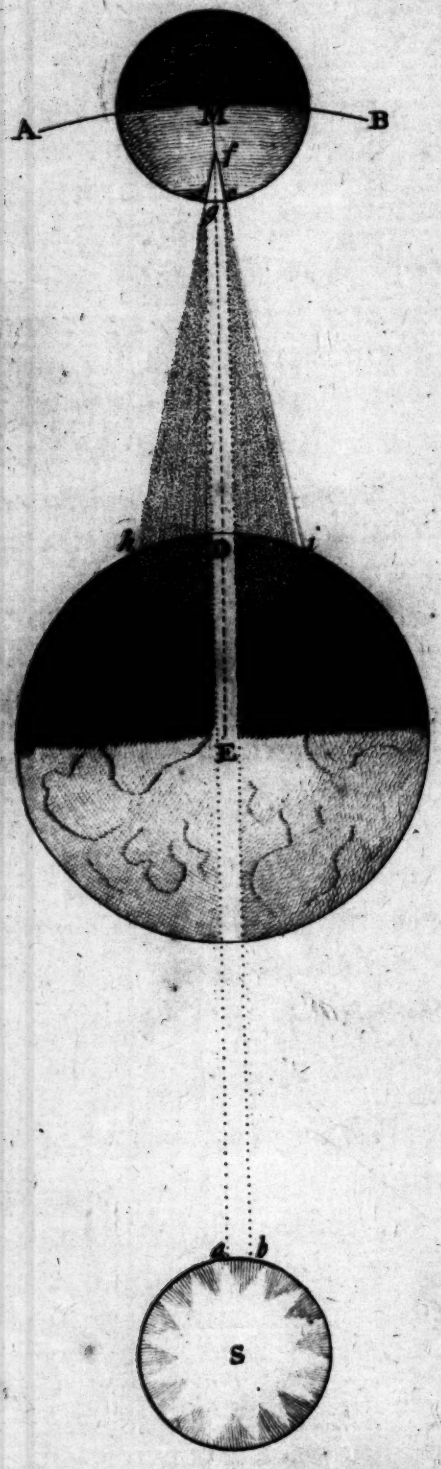

A
M
B
E
S

PLATE V.

This example explains the reaſoning introduced in the LECTURE, page 47, by ſhewing the divergence of the rays of light after they are reflected from the moon.

S the Sun, E the Earth, M the Moon, which, in its courſe A B, is ſuppoſed to be arrived at a ſtation *oppoſite* to the ſun (*i. e.* at full), from whence reflection may be conſidered as moſt *direct* and perfect. *a b* is a ray iſſuing from the ſun, and croſſing the earth, in order to arrive at M; now as parallel rays reflected from a ſphere, are not to be calculated from its vertex, but from half a ſemi-diameter diſtant from it, inſtead of beginning at M, we commence our calculation at *f*, lines drawn from *f* through *d* and *e* (where the ray firſt ſtrikes the moon) are diverged to *h* and *i*, continually becoming thinner and weaker as they widen and ſpread on all ſides. So that the ſame quantity of light which, when it left M, occupied only the ſpace *d e*, now occupies the much larger ſpace *h i*. As therefore the *ſquare* of *h i* is to the *ſquare* of *d e*, ſuch is the denſity of the rays at D. Or, as the *ſquare* of *f g* (554 miles) is to the *ſquare* of *f* D (235,450 miles); ſuch is the denſity at D (187,000 to 1 nearly): and in ſuch proportion muſt a lunar ray be re-condenſed to equal a ſolar ray.

If the moon was a perfectly ſmooth and poliſhed body, perhaps we ſhould ſee little more of her than ſuch a gliſten as *d e*: but being mountainous and rough, thoſe irregularities reflect light (whereby ſhe is viſible to us) on all ſides; now the obliquity of ſuch reflections and re-reflections muſt greatly weaken the force of the light, and probably abſorb much of it,—inſomuch that ſome perſons think themſelves juſtified by experiment, in aſſerting, that to render lunar rays equal to ſolar, they muſt be condenſed THREE MILLIONS OF TIMES.

LECTURE IV.

HAVING lately repreſented the ſolar orb as an immenſe globe of liquid fire, conſtantly agitated, and, with inceſſant vehemence, rolling from its ſurface vaſt floods of light, it may ſeem to need an apology, when I requeſt you, LADIES and GENTLEMEN, to accompany me in an excurſion to that luminary: what mortal foot ſhall ſtand on waves of fire! what native of earth ſupport the ſplendor of refulgent light!

Deſcend from heaven, URANIA, heavenly born,
Wiſdom thy ſiſter!——Up led by thee
Into the heaven of heavens, we may preſume,
Though earthly gueſts, and draw empyreal air,
Thy tempering:————

Our buſineſs here, is, not to examine the refulgent orb itſelf, to admire its brightneſs, explore its qualities, or aſſociate with its inhabitants (if it is inhabited); as ſtranger viſitants, we merely requeſt a ſtation upon its ſurface, from whence to ſurvey the regions of ſpace around us.

Shall we now imagine ourſelves participating ſolar vigour, while viewing the reflective planets in their ſeveral orbits; our viſual powers not dazzled, but confirmed; not debaſed, but exalted.

Firſt, let me point you to that extremely bright little ſtar, which, being neareſt, enjoys the greateſt brilliancy of the ſolar rays, and reflects them with ſprightly luſtre. Mortals on earth have

have called it MERCURY; and by that name we will ſtill diſtinguiſh it. Somewhat further off, you ſee (II.) VENUS; as the terreſtrials denominate it. The next is (III.) the EARTH itſelf; beyond it (IV.) MARS; then (V.) JUPITER; then (VI.) SATURN;—that, ſtill more remote, is what has lately been diſcovered to be a planet by Mr. HERSCHELL, and by him named (VII.) the GEORGIAN *planet*, in honor of our preſent Sovereign, in whoſe reign its nature was firſt aſcertained. If I were maſter of, and might beſtow, powers equal to prophetic viſion, or if we poſſeſſed the ſurvey of angels, I might hope to communicate an idea of the immenſe intervals between theſe bodies; might tell you, that Mercury is ONLY *thirty-two millions* of miles diſtant from our preſent ſtation (the ſun), that Venus is BUT *fifty-nine* millions of miles, and the Earth *no more* than *eighty-two* millions: do you ſmile at *only* and *but*, as applied to theſe numbers of the inferior planets; what then will you think of Mars, diſtant *one hundred twenty-three* millions; or how will you calculate *four hundred and twenty-four* millions, the diſtance of Jupiter? Yet this is not the whole extent which requires your ſurvey, for Saturn is diſtant *ſeven hundred and ſeventy-ſeven* millions: and the Georgium Sidus is very far beyond him.——

Nay, I beſeech you, ſtartle not even at this; for theſe are only the meaſured diſtances of regularly revolving ſtars, whoſe courſes maintain uniformity and (nearly) equation of diſtance. There are others, whoſe revolutions are ſo eccentric, that upwards of *five hundred years* is conſumed in one courſe round the ſun; theſe (comets) are numerous; and differ from planets, in that they are not ſtationed fixedly from

him

him, but now approach him closely, now fly off into the immensity of space.

When we consider the vast bulk of our station (the sun), whereby he is fitted to be the centre of the system, and whereby his attractive power extends immeasurably around him, we must admit the possibility, that other (perhaps many other) planets may be placed at still greater intervals; and this seems rendered yet more likely, by the extreme remoteness to which the cometary orbits extend; for if, at that distance, the sun's power revolves and draws back those bodies, why may it not also determine the courses of others in regular and planetary orbits? The comets will engage our attention in their proper place.

Supposing ourselves in the sun, we should see the planets before mentioned describing a path in the heavens, as *among the stars*; under which idea we offer a few remarks: (1.) Were a spectator in the sun to view a whole revolution of the planets, they would appear to move round him from right hand to left; in motions steady and regular, to make no stop nor delay in their courses, nor would he perceive more speed at one time than at another. (2.) That although they would appear to move in nearly the same plane, yet it would not be *exactly* so; but it would very rarely happen, even in many revolutions, that one should hide another; they would be either a little higher, or a little lower, so that in general they would all be visible. (3.) That if we suppose they were all in one direct line from him (I say if looking forward, he saw them all in one line) when beginning his observation, yet, by reason of the smaller orbits of some, and their consequent differences of apparent velocity,

such

ſuch a regular line would quickly appear diſordered; one might perhaps have got a quarter of his orbit, another an eighth, another a tenth part, and ſo on:—further ſtill, when one had appeared to have proceeded half his revolution, and the ſpectator wiſhing to obſerve him, muſt turn his back to his original ſtation, yet in that ſtation he would leave ſome who had made inconſiderable progreſs; and, in fact, they would appear ſcarcely to have moved by the time others had completed their courſes. (4.) As theſe planets ſhine by light borrowed from the ſun, each would *always* ſhew its illuminated half to the ſun, and appear to the ſun (without any change) as the moon does to us when full.

All the planets appear white or luminous; becauſe their ſurfaces reflect the rays of light as they receive them from the ſun, except that refraction of them on their rough ſurfaces, which we mentioned before with regard to the moon, whereby we are enabled to ſee them. There is however ſome little difference in the colours of the planets, as their ſurfaces are differently modified. Venus is a little inclined toward yellow; Mars is ſomewhat reddiſh; Jupiter very white; and Saturn a little livid; one reaſon of which may be his great diſtance.

It is ſelf-evident that if we ſuppoſe the planets to move with equal velocity, thoſe who have the leaſt ſpace to go through, will get firſt to the end of their courſes; for, if ſeen from the ſun they preſerved conſtantly a ſtrait line, reflect how prodigiouſly ſwift muſt be the motion of thoſe at great diſtances, or how prodigiouſly ſlow the motion of thoſe nearer; and this without any beneficial conſequences.

The

The periodical times of the planets may be expreſſed in round numbers, by ſaying, that Mercury goes round the ſun in three months; Venus in ſeven months; the earth in twelve months; Mars in two years; Jupiter in twelve years; Saturn in thirty years; and the Georgium Sidus is thought to take ſeventy or eighty years to complete a revolution.

We remark here, LADIES and GENTLEMEN, that there is a regular ratio between the times taken by the planets to complete their revolutions, and the diſtances at which they are placed from the ſun: thus Mercury, who is diſtant thirty-two millions of miles, takes but three months; while Venus, whoſe diſtance is greater (conſequently has more ſpace to paſs over in her orbit), is allowed a proportionally greater time, ſhe taking ſeven months, and being diſtant 59 millions of miles: the earth requires twelve months to perform a courſe, whoſe diſtance from the ſun is 82 millions of miles. Double the time is allowed to Mars, becauſe his orbit is nearly double this diſtance, being 123 millions of miles; and Jupiter and Saturn are indulged with many years, becauſe the diſtance of the firſt is 424 millions of miles; and that of the latter is 777 millions of miles; to which thirty years are not more than adequate. The diſtance of the new planet, is perhaps 12 or 1500 millions, to 80 years.

Theſe diſtances, containing ſo many millions of miles, are ſomewhat inconvenient to the mind, and apt to burden the memory; for abbreviation, therefore, we may conceive the diſtance of the earth from the ſun, to be divided into *ten* parts: at the diſtance of four ſuch parts from the ſun, we may eſtimate Mercury; Venus at ſeven ſuch parts; the earth, as we have

ſaid,

ſaid, at ten ſuch parts; Mars at fifteen, that is to ſay, *half as far again* as the earth; Jupiter at fifty-two ſuch parts, *i. e.* upwards of *five times* as far from the ſun as ourſelves; and Saturn at ninety-five ſuch parts, between nine and ten times our diſtance from the central ſun.

It is to be underſtood, that though we have thus ſtated the diſtances of the planets from the ſun, and though we have ſaid, a ſpectator in the ſun would not perceive them nearer or further diſtant; yet, in reality, they are, at ſome parts of their orbits, a little *further* from the ſun than their mean diſtance; as at another, *i. e.* the oppoſite part of their orbits, they are rather *nearer* to him than their mean diſtance. If I knew any one Engliſh word which would expreſs *nearer-to-the-ſun*, or, *further-from-the-ſun*, I would readily adopt it, and omit the Greek; but as our language affords no adequate expreſſion, we muſt of neceſſity accept aſſiſtance. *Helios* is the Greek name for the ſun; *peri*, near to; conjoin theſe: *Peri-helios*, is near-to-the ſun; the neareſt diſtance of a planet to the ſun, is therefore termed its *Perihelion*. The converſe of this idea we muſt next explain, expreſſing diſtance by *aph-helios*, remote from the ſun; and the greateſt diſtance of a planet is accordingly termed its *Aphelion*. Theſe points, we muſt remember, are always *oppoſite* to each other in the orbit of a planet. The perihelions of the planets are not all in the ſame point of the heavens, but vary.

It will occur to you, LADIES and GENTLEMEN, that thoſe bodies neareſt the ſun muſt needs receive moſt of the ſun's light, and that the light muſt produce proportionally greater

effects upon them; there is therefore provision made for their sustaining these effects, by a variation in the densities of these bodies. Mercury, which is nearest to the solar body, is the most compact, close, and dense; Saturn, which is so extremely distant, is of looser texture, and less compact; the Earth, which is between these planets, is between them in density. The difference is not very considerable; but as it seems to be a provision appointed by Infinite Wisdom, it is not, cannot be unworthy our notice.

We will just make one observation more, which is, that the whole bulk of the planets united, is but about one six hundred and fiftieth part the bulk of the sun; and then, if you please, we will notice these bodies in order. Angels, perhaps, may spring through the system, from extreme to extreme; we will modestly content ourselves with shorter journeys, and accept each planet as a resting-place.

MERCURY is the nearest planet to the sun; the eccentricity of his orbit is considerable, being above one-fifth part his mean distance, or the semi-diameter of his orbit. In bulk, he is the smallest of the planets, being in diameter only 2,160 miles. His light is extremely bright and lively, owing probably to his nearness to the sun. He circulates round the sun in 87 days, 23 hours, 16 minutes. He has no moon; nor from his situation has he need of any.

VENUS is the next planet to Mercury: she moves in nearly a circle round the sun; her axis is somewhat inclined from the plane of her orbit. Her bulk is much the same as that of the earth, she being 7,900 miles in diameter; her light splendid;

ſplendid; moſt probably has no moon (though ſome aſtronomers have imagined they diſcovered one); circulates round the ſun in 224 days, 16 hours, 49 minutes. Spots have been ſeen on her ſurface, whereby ſhe is thought to have a daily rotation on her axis in 23 hours; and this ſeems more probable (by analogy with the other planets) than what ſome gentlemen have thought, who have given for her rotation 24 days, 8 hours. It is to be remarked of this planet, that inſtead of revolving from weſt to eaſt, as the earth, &c. does, *i. e.* nearly with a *horizontal* motion, ſhe revolves almoſt north and ſouth, *i. e.* with a motion within 7 degrees of *perpendicular*.

THE EARTH moves in nearly a circle round the ſun (her eccentricity being only ſeventeen parts in a thouſand); her axis is greatly inclined to the plane of her orbit, no leſs than 23 degrees, 30 minutes: ſhe is 7,935 miles in diameter, has one moon (which circulates round her in 29 days, 12 hours, 44 minutes, turning in the ſame time on her own axis, and ſhewing ſpots), has a daily rotation on her axis in twenty-four hours.

MARS has an eccentricity of his orbit, nearly one-tenth part of its ſemi-diameter; his axis is not perceptibly inclined to the plane of his orbit: his diameter is 4,800 miles; he has no moon, but a very large and denſe atmoſphere, which probably performs ſome of the offices of ſuch an attendant. His daily rotation on his axis is performed in 24 hours, 40 minutes, as is calculated by his ſpots.

JUPITER's eccentricity is about one-twentieth part the ſemi-diameter of his orbit (48 parts of 1000); his axis is inclined to the plane of his orbit ſcarce at all; his diameter is 77,000 miles,

miles, being by much the largeſt of the planets, and nine times the bulk of our earth. He has four moons;

The *firſt*, diſtant from his body five ſemi-diameters and three-quarters; revolves in one day and three-quarters.

The *ſecond*, nine ſemi-diameters; revolves in three days and rather more than a half.

The *third*, upwards of fourteen ſemi-diameters and a quarter; revolves in ſeven days, three hours, and three quarters.

The *fourth*, twenty-five ſemi-diameters and a quarter; revolves in ſixteen days and nearly three quarters.

His ſpots are ſo conſiderable, and ſeem to occupy ſo great part of his ſurface, and in ſuch directions, that they are denominated his *Belts*: what they are, is not determined; their appearance often varies. His daily rotation is performed in 9 hours 56 minutes. The figure of Jupiter is not that of an exact globe; his diameter, at his equator, being longer than his diameter between his poles, as 13 to 12.

SATURN's eccentricity is rather more than one-twentieth part the ſemi-diameter of his orbit (fifty-five parts in 1000); his diameter 67,000 miles; which is 10,000 leſs than Jupiter. He has five moons:

The *firſt*, diſtant from his body, nearly five ſemi-diameters of the planet; revolves in leſs than two days.

The *ſecond*, diſtant ſix ſemi-diameters and a quarter; revolves in two days, ſeventeen hours, three quarters.

The *third*, diſtant eight ſemi-diameters and three-quarters; revolves in four days and a half.

The

The *fourth*, diſtant twenty ſemi-diameters and a quarter; revolves in fifteen days, twenty-two hours, three quarters.

The *fifth*, diſtant fifty-nine ſemi-diameters and upwards; revolves in ſeventy-nine days, ſeven hours, three quarters.

Beſide theſe five moons, he has a very wonderful apparatus called his *Ring*; which encompaſſes his body at a certain diſtance, and is reſplendent. His daily rotation is not determinable, his diſtance rendering his ſpots very obſcure. His ring is thought to have a rotation, and to be 20,000 miles acroſs. In proportion to the planet, it is about twice and one-third his diameter.

Thus, LADIES and GENTLEMEN, have we noticed the planets as they are related to the ſun, and ſeen from him as a ſtation: they have ſome other peculiarities as ſeen from the earth; but thoſe we propoſe to explain hereafter. Accept, at preſent, a few concluding hints.

Give me leave here to remind you, with what difficulty we form any idea of diſtances ſo extenſive as thoſe of the planets: we conceive very readily of a yard, or of a mile, becauſe the meaſure is familiar to us. To thoſe of us who have journeyed an hundred miles (or to any of my auditors who have viſited India) the diſtance is within comprehenſion; but when I ſpeak of a million of miles, when I ſay fifty, or an hundred millions of miles, who comprehends the computation? We are rather inclined to accept it as an inſtance of the powers of numbers, than as actual meaſurement of ſpace; and becauſe unaccuſtomed to a ſcale of ſuch magnitude, we are perplexed at the extenſion we can neither comprehend nor deny. We pretty much reſemble an honeſt native of St. KILDA (an iſland in the Atlantic Ocean, a little diſtant from Scotland, whoſe inhabitants are a few fami-

lies in native ſimplicity); this uninformed ruſtic had never quitted his rock, nor ſeen other ſhores; he had heard of Scotland, and only heard of it: when conveyed to the neareſt coaſt, what an immenſe voyage had he not accompliſhed! his ideas never conceived ſo great a ſpace. When, on a gentle acclivity, he ſurveyed the adjacent country, it exceeded now his belief, though he ſaw it with his eyes, as before it had exceeded his comprehenſion: with what ſenſations would this ſimple ſwain have beheld a globe, if we could ſuppoſe him to underſtand it, or what effect would the relation of a voyage to China have had on his mind! But ſurely the dimenſions of the globe were not leſſened, becauſe his ideas were contracted; and what ſhould we think of his denial that ſuch or ſuch places exiſted? It was remarked of him, that he could not underſtand the mechaniſm of a coach-wheel; yet we know that coach-wheels revolve; and ſo will the planets continue their courſes, whatever be the ſentiments they excite in our minds.

What power impels them round the ſun? They follow now the laws of that motion firſt impreſſed upon them, when their Almighty Maker ſpake, and it was completed; commanded, and it was done. Their courſes were appointed by Infinite Wiſdom, directed by unerring ſkill, and accompliſhed by ſupreme energy. That Power only which could create them was competent to conduct them, and by the impreſſion of that Power they revolve. But although we refer to Divine Omnipotence the ability to put in motion, and to continue in motion, theſe immenſe globes, yet, by the compariſon of great things with ſmall, we acquire ſome inſight into the laws and regula-

tions, whereby they are now governed. The moſt familiar inſtance I recollect, which explains the nature of the planetary motions, is this: you have often whirled around your finger a ſmall weight at the end of a ſtring; if you had ſuddenly quitted the ſtring, the weight would have quitted the circular motion you had given it, and would have fled from you in a ſtrait direction, prompted by its natural inclination; which very inclination, contributed to its motion while you held it, and that motion by your hold of the ſtring was circular, (*i. e.* around your hand as a centre.) Here your hand repreſents the ſun, and the ſtring repreſents the ſolar attraction. If we ſuppoſe the planets deſirous of eſcaping from their places, they are prevented by this attraction, which acting equally all around the circumference of their courſe, affords them no advantage whereby to elude its vigilance; nor can the force of this attraction diminiſh or increaſe, ſince, ſuch as it was, ſuch it continues, counterbalanced, by the interval of proportionate diſtance.

The ſame power which appointed the orbits of the planets, directed their courſes, and confined them nearly parallel: it might have been otherwiſe; ſome orbits might have been horizontal, others perpendicular (the comets are ſo); but Wiſdom has decreed, and the planets obey. If thoſe among mankind who ſcorn confinement and reſtriction, who think ever to be uncontrolled, and to follow without impediment the impulſes of their own hearts, would but reflect a little at the confuſion ſuch principles (or rather want of principles) would occaſion in the very ſyſtem of the world, they would ſurely be of opinion that no exiſtent creature can be free from reſtraint, but that order

is as neceſſary as being: how then ſhould man, whoſe importance renders him worthy attention, and whoſe propenſities require regulations, and whoſe welfare is promoted by them, how ſhould he be free? Abſolute freedom is ruinous licentiouſneſs: let us rather deſire to fulfil aright our deſtined courſes, and if, in the courſes of our friends, we obſerve any eccentricities, let us hope a little time will reſtore them to their juſt ſituations.

Having noticed the planets, I ſhall juſt offer a remark on the nature of COMETS. You know theſe were once thought to prognoſticate direful events, bloodſhed, war, devaſtation, and (worſe than eclipſes!) were regarded as ominous forerunners of final diſſolution. Better informed ſcience conſiders theſe tremendous ſtrangers as revolving in orbits as regular and periodical as the planets themſelves; the principal difference being, that the diſtance of the planets is conſtant and circular, while the cometary orbits are ſo exceedingly elliptical, that ſome of them ſeem to advance to the ſun in nearly a ſtrait line, and to return in a line not ſenſibly different. Moreover, the extremes of this line are extremes indeed, at its neareſt approach to the ſun, almoſt ſtriking that reſplendent orb; at its furtheſt receſs, diſtant immenſely beyond the ſtation of any known planet. There is great variety and difference in the orbits of comets; ſome ſtretching prodigiouſly into ſpace, ſo as to require above five hundred years to complete a revolution; others advancing little nearer to the ſun than the orbit of Mercury, and completing a period in ſeventy-five years; ſome revolving round the ſun in one plane, others in a contrary; ſome flying on the

right-

right-hand, others on the left; ſome above, ſome below; yet all agree in revolving round him: indeed, it is extremely probable that many comets have never been noticed, having advanced to the ſun in ſuch a manner as to conceal their diſtinguiſhing character, the *train of tail*, which, at their advance to the ſun, kindles and increaſes by degrees; at their return from the ſun, by degrees decays and ceaſes.

Comets are alſo of different magnitudes; perhaps we ſcarce diſcern the ſmaller; or if we diſcern, we do not diſtinguiſh them from conſtant ſtars. I have ſometimes indulged myſelf in conſidering, what might be the uſe of comets: do they come to the ſun to import fire and heat which they carry to the remoter parts of their ſyſtem? Are they connecting links between ſyſtem and ſyſtem? I cannot but think other ſyſtems have their comets, which approach near enough to us to be ſeen (perhaps they are miſtaken from time to time for new ſtars), as ours perhaps may approach and be viſible to others. This ſeems likely:—that at their acceſs to the ſun they are extremely heated, at their ultimate diſtance they undergo exceſs of cold.

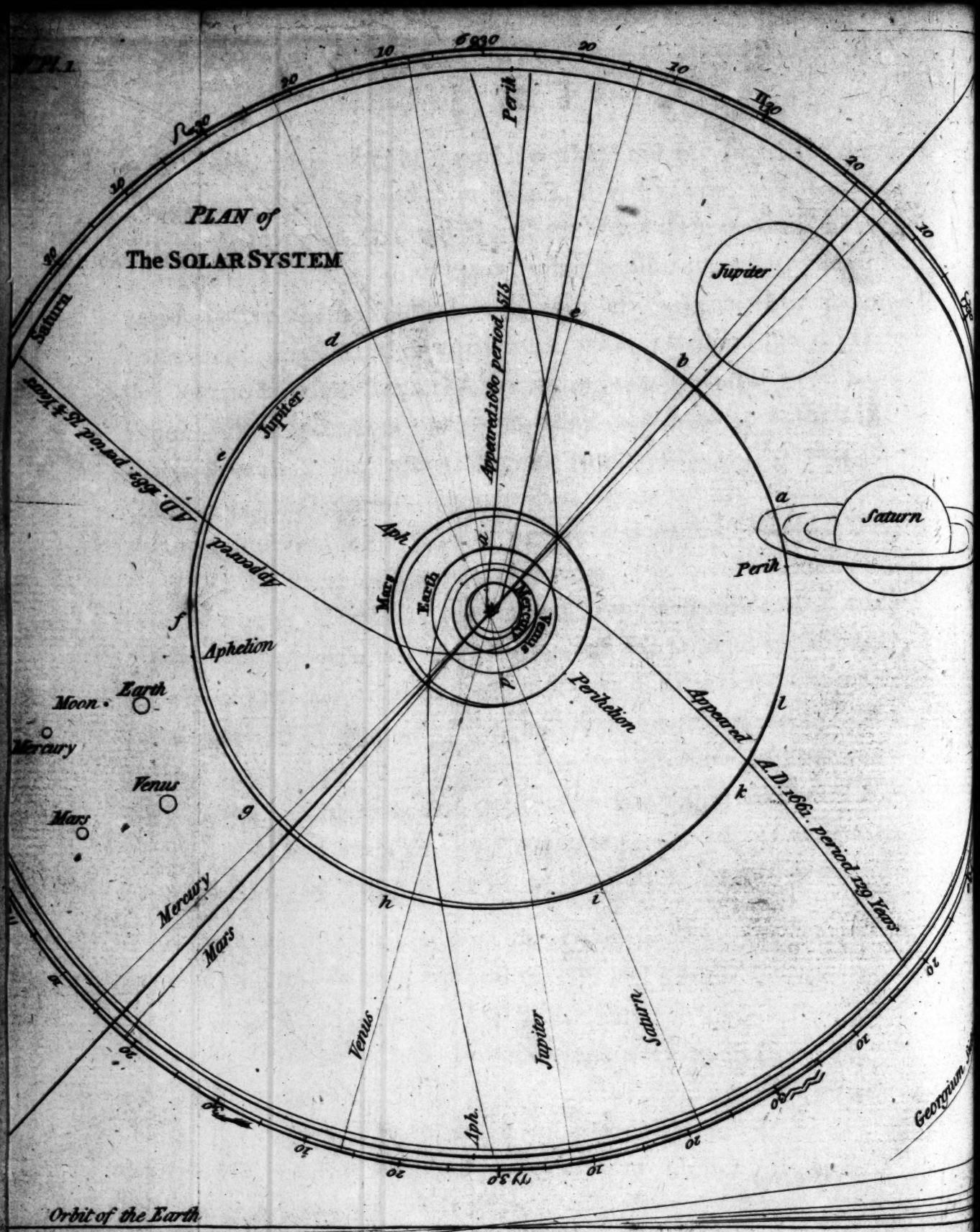
Sir ISAAC NEWTON thought, comets might ſupply moiſture to the planets, from time to time, by means of the vapour of their tails; and from time to time, by falling into the ſun, might contribute freſh fuel to repair the waſte of that fountain of light. —O for the ultimatum of human inquiry; for the bounds of human curioſity!

Are the planets inhabited? I ſcruple not to affirm it: are the comets? we cannot tell: but, as has been hinted, they ſeem ſubject to extremes, now glowing with ſolar fire, now frozen with

with the energy of cold; perhaps they are not fitted for dwellings: accept it ſo; and then reflect, if you pleaſe, that we have comets here on earth; we ſee them from time to time among mankind; how they now blaze! what brilliancy, what ſplendour accompanies them! they ſcorch with enjoyment, they accompany and emulate the very ſun: what commotions do they not excite! what remarks do they not occaſion!—Wait a little:—their ſplendour weakens, their pomp declines, their diſtinction ceaſes, they are viſible no more: inferior in this reſpect to celeſtial comets, which ſhall again return, theſe when extinguiſhed become "ſtars of perpetual darkneſs!"——

While the more ordinary and regular, the conſtant, and ſtationary planet, affords habitation and ſupport to millions of creatures; while it receives the bleſſings of millions of inhabitants, by whom it is cultivated and adorned; while it enjoys the grateful viciſſitude of day and night, an equable temperament, and a laſting ſhare of celeſtial influences, it may well view without envy the cometary perihelion, and rather pity than regret cometary diſtinction: is this in no reſpect analogous to incidents of human life? If it is, the planetary orbit be the ſtation for me!——

OBSER-



ELEVATION of the Solar System.

a, Orbit of Mercury. b, of Venus. c, of Saturn. d, of Mars. e, of Jupiter.

OBSERVATIONS on the PLATE

Belonging to LECTURE IV.

THIS plate compriſes as complete a view of the ſolar ſyſtem, as perhaps can poſſibly be contrived on one plate: and it is to be conſidered as containing,

(I.) A plan of the orbits of the planets compoſing the ſolar ſyſtem.

(II.) The proportions of the planets to the ſun.

(III.) An elevation of the orbits of the planets, as conceived to be ſeen from the ſun.

(IV.) The places of the nodes of the planetary orbits with the orbit of the earth.

(V.) A ſpecimen of the contradictory orbits of comets.

OF THESE IN ORDER,

(I.) In the centre is placed the ſun; around whom revolve, (1) MERCURY, whoſe orbit appears to be at one time much further from the ſun than at another; the thin line denoting a really circular courſe, the black line the actual courſe of this planet. His *aphelion* and *perihelion* are very evident. (2.) VENUS, whoſe orbit is nearly circular; the aphelion part of it, therefore, only denoted by its ſtronger blackneſs. (3.) The EARTH, whoſe orbit alſo is nearly circular; its aphelion marked

marked *a*, its perihelion *p*. (4.) MARS, whoſe orbit has conſiderable eccentricity: his actual courſe diſtinguiſhed by its ſtrength. (5.) Jupiter; and (6.) SATURN, whoſe courſes are diſtinguiſhed on the ſame principle.

[Around theſe orbits are placed the characters of the twelve ſigns, and their degrees; theſe ſerve equally to all the planets, ſo that as well Mercury, as Saturn, may be ſaid to be in a particular ſign, when ſeen from any ſtation it appears among the ſtars which compoſe that ſign. *N. B.* The degrees of the ſigns are reckoned from ſign to ſign, each containing thirty degrees: and not from any ſpecific point, and ſo continued throughout the circle.]

All the planets move the ſame way: and, ſeen from the ſun, appear to go round him (the ſame way as the ſun himſelf revolves) from right to left; according to the order of the letters marked on the orbit of Jupiter, *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *k*, *l*.

The GEORGIUM SIDUS, or the ſeventh planet, being but in part diſcovered, and the theory of his motions, *&c.* being at preſent imperfect, we have juſt hinted a notice of him. His orbit is far beyond Saturn, and if truly laid down, would have reduced the orbit of Saturn to half its preſent ſize, and have rendered hardly viſible the courſes of the inferior planets. It was thought better, therefore, to admit an inaccuracy in the place of this orbit, than confuſion in the others.

(II.) The PROPORTION of the planets to the ſun, appears by a compariſon of them with the line S, S; which repreſents the

diameter of the ſolar orb.—The real dimenſions of theſe bodies have been noticed in the lecture.

(III.) ELEVATION of the orbit of the planets, as ſeen from the ſun: theſe we obſerve are eſtimated by compariſon with the orbit of the earth, from which, we note, that Mercury differs in his courſe more than any other planet; his orbit, therefore, though the ſmalleſt of all, is the moſt irregular, (1.) as his eccentricity is greateſt, (2.) as the elevation, and depreſſion of his courſe is alſo greateſt. The orbit of Jupiter differs but little from that of the earth. In fact, with regard to what differences *might* have exiſted, the whole of the planetary courſes may be regarded as nearly ſimilar. The quantity of variation from the ecliptic is, as follows:

Mercury	6°	59′	20″	Jupiter	1°	20′	
Venus	3	23	5	Saturn	2	33	30
Mars	1	52					

(IV.) As the foregoing figure is under a neceſſity of ſuppoſing (what is falſe in fact), that the courſes of the planets croſs each other (*i. e.* form knots or nodes) in the middle of the elevation, it is the deſign of the thin lines, marked with the names of the planets, to correct this idea; accordingly, by attending to them, it appears, that the interſections of the planes of the planetary orbits with that of the earth, *i. e.* their nodes (ſuch planes ſuppoſed to be extended ſo as to meet the earth's orbit), are as follows:

The aſcending node of Mercury in ♉ (Taurus) 14° 42′
of Venus in ♊ (Gemini) 14 25 54″
of Mars in ♉ (Taurus) 18 29 54
of Jupiter in ♋ (Cancer) 7 19 54
of Saturn in ♋ (Cancer) 21 49 54

The deſcending nodes are of neceſſity diametrically oppoſite to the aſcending, and are marked on the plate by the names of the planets at length.

(V.) This plate exhibits alſo tracks of three COMETS, as ſpecimens of the liberty with which theſe bodies advance toward the ſun on all ſides: ſometimes from the right-hand, ſometimes from the left; ſometimes aſcending from below, ſometimes deſcending from above. We remark that ſuch courſes as are moſt *round*, are moſt ſpeedily terminated; while ſuch as are very narrow, and almoſt as it were parallel, are of very long duration. The number of comets is great; but theſe caſes are ſelected as being moſt contradictory.

LECTURE V.

LADIES and GENTLEMEN,

THE objects we conſidered in our laſt diſcourſe, magnificent as they are, are yet ſo remote from the earth we inhabit, that it ſeems natural to inquire of what advantage are they to us, and how do they appear when ſeen from our reſidence? But previous to anſwering theſe queſtions, our attention muſt be directed to a few obſervations.

If I was to aſk any one, where he lived? and he ſhould vaguely anſwer, on the earth; it is neceſſary to inquire further, on what part of it? But if he replies, in ſuch a town; I am enabled to find it on the globe which I inſpect, by inquiring its latitude and longitude; that is to ſay, by aſcertaining its relative ſituation to certain points from whence I begin my calculation: the globe itſelf is large, but by being divided into ſmaller ſpaces, which are perfectly regular, we readily find any one ſpace, and its ſmallneſs enables us to inſpect it accurately. Juſt ſo are the heavens; too extenſive to permit any determinate idea from a vague expreſſion, and, therefore, it has been found neceſſary to regulate, and divide their extent. The wandering planets afforded no ſettled rule for this procedure, and the ſun, though fixed and at reſt, contributed little towards it, becauſe he

ſeemed in motion. Recourſe was had to thoſe infinitely more diſtant ſtars whoſe permanent ſtations gave ſome *fixed* points for determination; and theſe were found applicable to the purpoſe, becauſe, the eye, unable to judge accurately of their diſtances, conſidered all the celeſtial bodies as equally remote.

The firſt application of ſuch principles, ſeems naturally to be to aſcertain the *apparent* path of the ſun in the heavens; according therefore as that luminary *ſeemed* to proceed gradually from place to place, and theſe places appeared among ſuch and ſuch ſtars, thoſe ſtars became of more conſequence, and were more accurately attended to than others.

I beg your attention while I ſuggeſt ſomewhat of this ſyſtem: whether the earth goes round the ſun, or the ſun goes round the earth (as he ſeems to do); the ſpectator will ever behold the ſun proceeding in the ſame orbit in the heavens. Now, in order to determine at any certain time, where in his annual orbit was the ſolar ſtation, it became neceſſary to divide this orbit into parts; accordingly, as ſeemed moſt analogous to other conſiderations, it has been divided into *twelve* parts (a correſponding number you ſee to the months of the year); and the ſtars which lay near to the ſolar path, by the fertile imaginations of the beholders being likened to certain forms, were taken to repreſent ſuch forms, in twelve diviſions, and relative names were appointed to each.

The path of the ſun was called the ECLIPTIC; and is not always of apparent equal height in the heavens, becauſe, as we formerly obſerved, the axis of the earth not being perpendicular

cular to the plane of its orbit (in other words, to the apparent path of the ſun round the earth, or the real path of the earth round the ſun), but inclined thereto; the ſun ſeems at one time to be heightened above his juſt ſtation, at another time to be depreſſed below it.

Mankind were originally cultivators of the earth; they plowed and ſowed, or they bred and tended cattle: theſe ideas, therefore, were ever uppermoſt in their minds, and willing to renew and maintain them, they tranſplanted their cattle even into the heavens. Or, having obſerved that at the time of the ſun's being in ſuch a diviſion of the ecliptic, their cattle were moſt prolific, they gave the names of ſuch as then brought forth their young, to that conſtellation which then entertained the ſun; and in the others they ſtill alluded to the courſe of their huſbandry.

We muſt now, LADIES and GENTLEMEN, imagine ourſelves tranſported to a climate, where the natural events of huſbandry would agree with the order of the conſtellations, or ſigns of the Ecliptic, for in this climate they will not juſtify the ſignifications attributed to them.

The conſtellations reckoned to the SPRING ſeaſon, are, the Ram, the Bull, the Twins (properly the two kids). The ram evidently alludes to the time of increaſe among the fleecy flock, as the bull does to the fertility of the horned herd; and if we adopt the ſuppoſition that the twins related to the goats, and not (as now delineated) to the human kind, we have the three chief objects of the ſhepherd's care, indicated in the ſigns of the ſpring-ſeaſon in the months of March, April, and May.

May. The SUMMER conſtellations—the Crab, the Lion, the Virgin (June, July, Auguſt), have been thus accounted for: the crab, being an animal which walks backward, is thought to have ſignified the retreating courſe of the ſun, which from Midſummer is regularly declining, having accompliſhed the higheſt reach of its path in the ecliptic. The ſign of the lion ſeems to imply, either, that at that time this ſavage animal was unuſually ferocious (being heated by the ardent beams of the ſun, and its natural fever increaſed), conſequently more deſtructive; or, that the heats of the ſeaſon, too nearly reſembling the lion by their fierceneſs, were no leſs fatal. The virgin, which follows the lion, is certainly no other than a reaper, holding in her hand three ears of corn. The AUTUMNAL ſigns are, the Balance, which ſeems clearly to expreſs the equality of days and nights in September. The Scorpion, having a venomous and miſchievous ſting, has been taken to ſignify, that where theſe ſigns were firſt adopted, the ſun left behind him diſeaſes and mortality in October: the Archer, or Huntſman, aptly expreſſes the exerciſe of the chace (in November) after vintage and harveſt are over. The wild Goat, the firſt of the WINTER ſigns (December), has been ſuppoſed to hint the return of the ſun, becauſe that animal is perpetually climbing and aſcending the ſteepeſt rocks. Impetuous Floods mark January, and the pair of Fiſh, ſeems well adapted to the ſeaſon when thoſe creatures were objects of purſuit, in February.

The STATION of theſe ſigns in the heavens, is ten degrees on each ſide the ecliptic: ſo that they are included in a belt of twenty degrees broad, which, from theſe ideal figures of animals

mals, is called (the Animal-belt) in Greek the ZODIAC. The ſigns of the Zodiac are very ancient, ſo ancient, that I cannot but ſuſpect that during a lapſe of time, they are more or leſs changed from their original ideas; however, we accept them now as they are. The country where they were firſt adopted is uncertain, ſome authors contending for Egypt, others for India.

Thus, LADIES and GENTLEMEN, human induſtry and contrivance diſtinguiſhed the (apparent) path of the ſun from all other parts of the heavens; the paths of the planets varying but a few degrees from this courſe already aſcertained, the fixing of one readily determined the others.

We ſhall now, if you pleaſe, beſtow a few thoughts on each of theſe celeſtial bodies, as ſeen from the earth. Firſt, of the SUN: We have formerly noticed the immenſe magnitude of this object; but when ſurveyed from the diſtance at which the earth is ſtationed, he ſeems too ſmall to excite the idea of ſo vaſt a bulk: the mean apparent diameter of the ſun being thirty-two-minutes. You will remark, that I ſay his *mean* diameter, becauſe the earth in common with the other planets having her *perihelion*, and her *aphelion*, her nearneſs to the ſun in the former, increaſes his apparent magnitude to thirty-two minutes, thirty-ſeven ſeconds, as her greater diſtance in the latter, diminiſhes it to thirty-one minutes, thirty-two ſeconds.

Contrary to what might be ſuppoſed by curſory imagination in our part of the world, the perihelion of the earth is in December, ſo that we are really neareſt to the ſun in winter. Our ſeaſons therefore do not depend upon this circum-

ſtance, but are more nearly related to what I ſhall next obſerve, *viz.* that the courſe of the ſun in the heavens, is ſometimes very highly elevated above the horizon, ſometimes is but little diſtant from it. In mentioning the earth among the planets, we ſaid, her axis was inclined to the plane of her orbit ſo much as twenty-three degrees and a half: the conſequence naturally follows, that in the courſe of her annual revolution twenty-three degrees and a half of her ſurface towards each pole of her axis, is turned more immediately and directly to the ſun at one time than at an other: and by ſo much as ſhe turns more of any certain part of her ſurface toward the ſun, by ſo much longer is that part expoſed to the ſolar beams during her daily rotation. So that inſtead of having at London twelve hours day, and twelve hours night (as, if the earth was perpendicular to the plane of her orbit, we ſhould always have), we have ſometimes barely ſix, ſometimes more than ſixteen: as at the pole, they have ſometimes no day during two months (in winter), no night during two months (in ſummer). When we come to treat of the ſeaſons, this idea will naturally recur to our conſideration.

I ſhall now introduce a remark on a particular appearance of the MOON, as ſeen from the earth; which is, that at a certain time (from about the end of July, to the beginning of September) the moon, when juſt after the full, riſes ſeveral nights together ſoon after the ſun ſets; ſo that twilight is ſcarce begun, ere the moon appears, and prolongs the light, to the great benefit of thoſe who have harveſt-work to do, and is therefore called at that time the HARVEST-MOON: this depends

pends on the courſe of the moon, and her relative ſituation to the earth, and is one effect of that beneficial irregularity which we formerly noticed. [For the explanation of this ſubject vide the Plates.]

Beſide theſe appearances we obſerve that both the heavenly luminaries, when near our horizon, appear ſomewhat varied in form from their true ſhape, and alſo with enlarged dimenſions: this is moſt remarkable with regard to the moon.——

It can ſcarcely have eſcaped your notice, LADIES and GENTLEMEN, that the moon ſeems very much larger than ſhe ſhould do, when ſeen in this ſituation; the cauſe has been much debated—certainly, the cauſe is near ourſelves; but whether ariſing from the vapours of our horizon, or from a compariſon with other objects to which ſhe is near, or from the effect of her light (which is but weak) on the eye, philoſophers are not ſatisfied. For my own part I think the terreſtrial vapours contribute the greateſt ſhare to this peculiarity; and it ſhould ſeem to be moſt ſenſible, when the atmoſphere is moſt loaded with tranſparent vapours: but this is agreed, that, when meaſured by the teleſcope, no variation of diameter can be diſcovered.

The mean apparent diameter of the moon is thirty-one minutes, ſixteen ſeconds; her ſmalleſt diameter is thirty-one minutes, three ſeconds; her largeſt, thirty-one minutes, thirty-eight ſeconds.

We will next, if you pleaſe, ſtep over the interval from the ſun to the planets. You will remember that we are not now (as before) ſurveying the planets from the ſun, but from the earth, and therefore we may, without offence, adopt what-

ever notions of the inhabitants of earth are not contradictory to nature and to fact. It is uſual to denominate thoſe planets nearer to the ſun than ourſelves, *inferior*, and thoſe further from the ſun than ourſelves, *ſuperior*. The inferior planets conſequently are Mercury, and Venus. Theſe have ſo many appearances in common, that when we have attained a diſtinct idea of either, we have little to add concerning the other.

I ſhall now requeſt your attention to what is common to both, (1.) The courſe of their motions being *within* the courſe of our motion with regard to the ſun, it will naturally happen that they ſometimes are exactly between the ſun and the earth, ſo that looking to the ſun we ſhould (ſuppoſing their light ſtrong enough) ſee the planets alſo; and this muſt needs be their neareſt approach to the earth, or *Peri-Geo* (*Ge* being the Greek name for the Earth—Vide a ſimilar explanation, page 65); and not only may the planets be thus in *conjunction* with the ſun, but if the conjunction be abſolutely *perfect*, a line drawn from the ſun to the earth, will paſs through the body of the planet; hereby the planet intercepts ſo many of the ſolar rays, as are proportionate to its magnitude, and eclipſes to a certain degree the ſun from us. This paſſage of a planet over the face of the ſun, is called a *Tranſit*, and can only happen to inferior planets. Thus, Venus may ſee a tranſit of Mercury; the earth of Venus and Mercury; Mars of the earth alſo, and ſo on. But Mercury never ſees a tranſit of Venus, becauſe the path of that planet never lies *within* (but always *without*) his orbit. Tranſits are very rare.

(2.) We have ſuppoſed the planet between the earth and the ſun

ſun (this is called an inferior conjunction); but it is evident, that the ſame planet, in purſuing its courſe, muſt ſometimes be beyond the ſun—from us: ſo that the ſun ſhould be between us and the planet (this is a ſuperior conjunction), inſomuch that the ſun may paſs over the face of the planet, as before the planet paſſed over the face of the ſun. When a planet is thus ſituated, the effulgence of the ſun's rays prevents its being viſible in any degree whatever. There are therefore two periods at which the inferior planets are to us inviſible, *i. e.* the conjunctions, when the ſun's rays are coincident with the planet, and too powerful for it. Add to this, that in the inferior conjunction, the illuminated face of the planet being turned toward the ſun, the dark part is conſequently turned toward us. So that theſe planets pretty nearly reſemble the courſe of our moon, being new (or dark), horned, half-light, full, and ſo on, in the progreſs of each revolution.

If the earth was not herſelf a planet, but fixed, theſe conjunctions would happen in every revolution of theſe planets round the ſun; but as the earth moves as well as the planets, conjunctions can only happen when two planets are in the ſame part of the heavens, ſeen from the ſun.

But though the earth is a planet, we will for a while ſuppoſe her at reſt: thus ſituated, we attend to one revolution of the planet Venus; and we note, that ſhe firſt paſſes pretty briſkly in her courſe, according to the order of the ſigns; but in a little time her pace ſlackens, ſhe ſtands quite ſtill, then ſhe returns back in her courſe, till again ſhe ſeems motionleſs, from which recovering ſhe reſumes her original progreſs, and

again

again advances in the order of the ſigns. This is the neceſſary effect of her circular courſe.

To render theſe appearances ſtill clearer, I have here a ſmall wheel, which I lay flat on the table; then erecting this wire upon any part of the circle (or periphery) of the wheel, I put on the top of the wire a ſmall object for convenience of ſeeing it; now I place a candle on one ſide of the wheel:—— trace, if you pleaſe, the ſhadow of the ball on the wainſcot, as I turn the wheel round—the ſhadow moves firſt (you ſee) to the left, then it returns to the right, at each revolution of the wheel; and at each extreme it ſeems to move with diminiſhed velocity.

The inferior planets can never be very much elongated from the ſun, but their greateſt diſtance from him will always be proportionate to the confined dimenſions of their orbits: thus Mercury, whoſe orbit is ſmall, is ſo conſtantly a neighbour to the ſun, that he was long unnoticed by the early aſtronomers. He is only to be ſeen for a little while after ſun-ſet, and a little while before ſun-riſe, and always in that quarter of the heavens where the ſun is, inſomuch, that during a great part of his courſe, he is obſcured by the ſolar beams. On the ſame principle Venus, though ſeen later in the evening than Mercury (her orbit being larger), yet always ſets before midnight.

If ſuch peculiarities in the courſes of theſe planets are not ſufficient to prove that they revolve round the ſun, yet I think we may defy the acuteſt maintainer of that ſyſtem which ſuppoſes them to revolve round the earth, to account for them fairly

Lecture V.
Plate I.

HARVEST MOON

Fig. 1

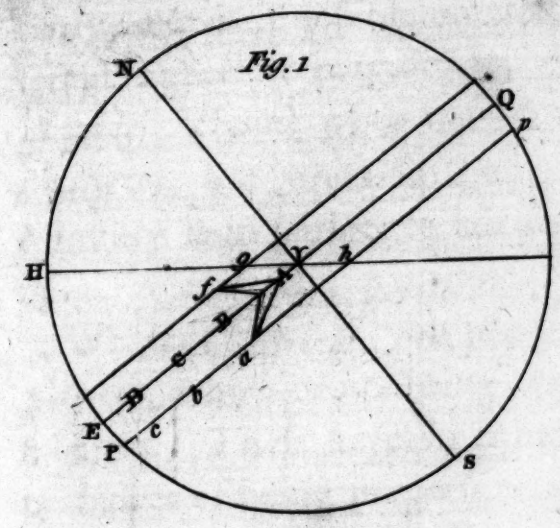


Fig. 2

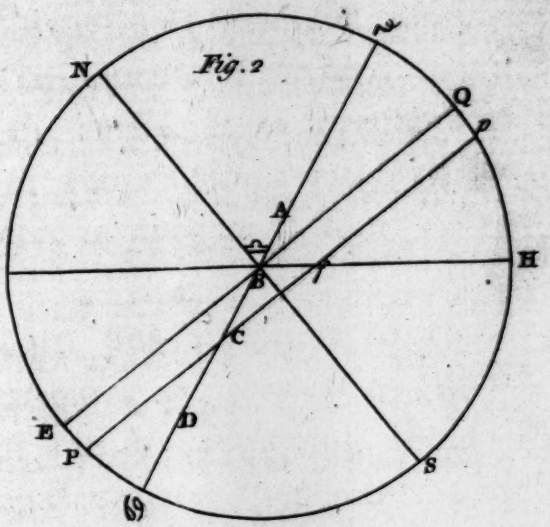


Fig. 3.

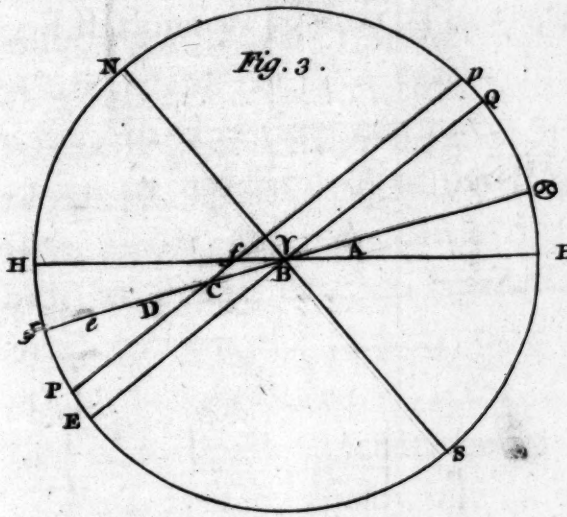


Fig. 4

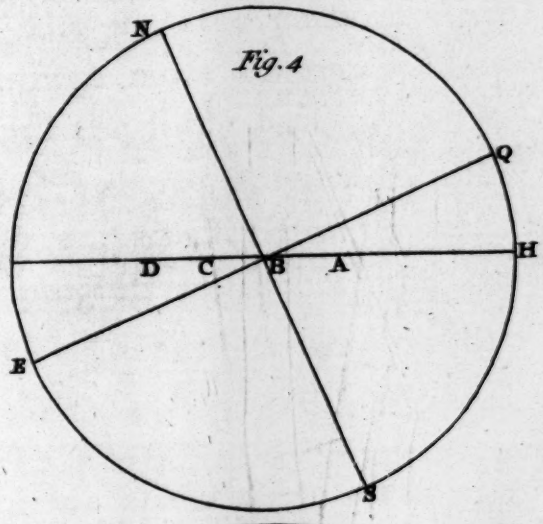


Fig. 5.

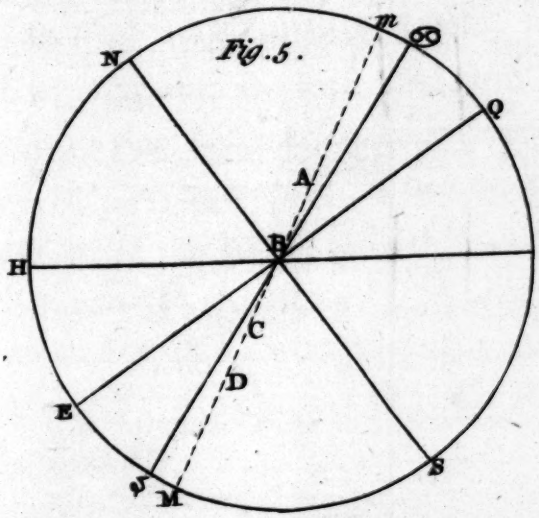
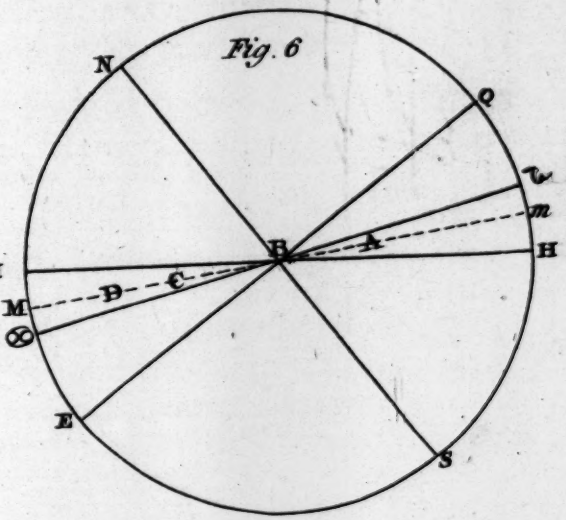


Fig. 6



HARVEST MOON

fairly; nor is it poſſible on that ſcheme to account for the different apparent magnitudes of theſe planets, in *perigeo* and *apogeo*. Venus, when neareſt to the earth, is as ſeventeen in diameter, but when furtheſt from the earth as only three. Mercury is in perigee to his diameter in apogee, as fourteen to ſix.

We will now, if you pleaſe, turn our attention to thoſe planets, whoſe orbits being *without* ours, are termed Superior Planets. Theſe have, in common with the foregoing, the appearances of being progreſſive, then ſtationary, then retrograde, and ſtationary again. They are alſo in ſome parts of their orbits nearer to the earth, in others more remote. They differ, in that they can never tranſit the ſun's face, or be between us and him. A conjunction of a planet is, when the ſun, that planet and the earth are in one exactly ſtraight line: but, as in this caſe, to trace the progreſs of ſuch a line, we muſt, to view the planet, turn our backs on the ſun, this ſituation of theſe bodies is termed *Oppoſition*; the proper conjunction of a ſuperior planet, being only when it is behind the ſun.

We ſuppoſed, that while an inferior planet went round the ſun the earth continued ſtill; let us now, if you pleaſe, change the ſuppoſition, and imagine that while the earth revolves round the ſun, a ſuperior planet (Mars, as being neareſt) remains permanent. The effect would be, that when the earth is fartheſt diſtant from the planet, the planet would ſeem direct in motion (*i. e.* according to the order of the ſigns); as the earth advanced in the *turn* of her courſe, as we may be allowed to call it, the planet would ſeem ſtationary, and

when the earth was in her neareſt ſemi-circle, the planet would ſeem retrograde. You eaſily conceive theſe variations from what I have already ſaid. And you will pleaſe to remember, that as neither of theſe bodies do in fact ſtand ſtill, the appearances will be proportionately varied.

We have heretofore obſerved, that the ſmaller the orbit of a planet, the ſooner it accompliſhes a revolution: Venus, for inſtance, who finiſhes her courſe in ſeven months (while the earth takes twelve), will be advanced five months in another courſe, by the time the earth has concluded her old one; as the earth will complete a whole revolution, and almoſt a ſecond, while Mars is fulfilling his orbit. The difference of the apparent velocities of two planets, is uſually calculated, by ſuppoſing a ſpectator in the ſun to obſerve their revolutions, and to eſtimate the daily difference of their motions. The daily mean motion of the earth, would appear to ſuch a ſpectator to be fifty-nine minutes, eight ſeconds; the daily mean motion of Venus, one degree, thirty-ſix minutes, eight ſeconds; the difference thirty-ſeven minutes: now, therefore, as thirty-ſeven minutes is to the whole circle of three hundred and ſixty degrees, ſo is one day to the whole courſe of Venus, till ſhe returns into the ſame relative ſituation to the earth (conjunction if you will), which requires about five hundred eighty-three days. The daily mean motion of Mars is thirty-one minutes, twenty-ſeven ſeconds; and the earth takes to recover any given ſituation with reſpect to Mars, two years and fifty days. The mean motion of Jupiter is four

minutes,

minutes, fifty-nine ſeconds daily: the interval (of a conjunction, &c.) is one year, thirty-three days. The mean motion of Saturn, is two minutes daily: the interval, one year, thirteen days. The motion of the Georgian planet is ſo ſlow, that his places are calculated only for one day in a fortnight, during which he ſcarce ſeems to change place at all. We obſerved of the inferior planets, that they ſhew to the earth the ſame changes in their lights as our moon does; the ſuperior planets never ſhew ſuch changes, but conſtantly ſhine full, except Mars, who is much darkened when in quadrature.

If, LADIES and GENTLEMEN, we had actually winged our way from planet to planet, we might have pronounced deciſively on their properties and natures, and might have aſcertained, what now we can only conjecture and ſuppoſe. It was not ſo proper in our laſt lecture, to deal in conjecture and ſuppoſition; but now that we are upon earth, we muſt mingle earth-like uncertainty with much of our information reſpecting theſe objects; and we may do it with the better grace, ſince experimental knowledge will not be expected from us.

MERCURY is ſo ſmall, ſo diſtant, and ſo near the ſun, that little can be added to what has been already hinted.

Of VENUS we remark, that we can ſee her longer than we can ſee Mercury; ſhe is ſometimes viſible only in an evening, and then called the Evening Star, or HESPERUS; ſometimes only in a morning, and then called the Morning Star, LUCIFER, or PHOSPHORUS: that is to ſay, before her inferior conjunction with the ſun, ſhe ſets after him;

after

after her conjunction, ſhe riſes before him, and increaſes the time of her appearance above the horizon, according to her diſtance from the ſun. The ſplendor of this planet is ſo lively, that at certain periods of her revolution ſhe is viſible even in the day-time: and her light is often brighter than an equal ſpace of light on the ſurface of the moon.

Of MARS I ſhall not add to what I have already obſerved.

JUPITER is of ſo great magnitude and brightneſs, and on account of his ſyſtem ſo important, that he muſt not be paſſed over in ſilence. It is a very pleaſing ſight through a teleſcope, to obſerve this planet with all his moons about him, like a parent whoſe children are conſtantly employed in his ſervice. Theſe moons, like our own, are *eclipſed* by paſſing through the ſhadow of their primary; as at other times, their primary receives a ſhadow from them. Theſe eclipſes have been propoſed as the readieſt way of determining the longitude on the earth; and to them we are indebted for the firſt proof of the travelling of light. [Explained on the plates.]

The ſyſtem of SATURN, is one of thoſe wonderful contrivances which contemns the efforts of human ſkill: what little we know of him (and his diſtance precludes the expectation of a perfect knowledge) excites our admiration. As ſeen from the earth, his moons are extremely ſmall, and only to be diſcerned by the beſt glaſſes, and in a favourable ſtate of the air. The appearance of his ring is conſtantly varying, as it is more or leſs oblique to our view, and to the ſolar rays; which ſometimes illuminate the upper, ſometimes the under ſurface of it, but which, when they ſtrike againſt its edge, are not re-

flected with ſufficient ſtrength to tranſmit light throughout an interval ſo prodigious.

After ſurveying ſuch an auguſt combination of wonderful ſtructures; after having traced the principles of their revolutions, and ſomewhat inſpected their appearances; it would be almoſt criminal in us to deny our improvement, as well in morals, as in knowledge; for ſurely, LADIES and GENTLEMEN, the variety, the order, the beauty, the conſtancy, the utility of theſe planetary globes, cannot be regarded without conſiderable emotion of mind.

We are taught by the higheſt authority, to look on all mankind as brethren; all mankind on the face of the earth: I may juſtly extend the precept, and regard as brethren all who tread the ſurface of our neighbour worlds. Need I ſcruple to conſider theſe worlds as ſo many reſidences of intelligent beings? I think not: how nearly they may be allied to ourſelves in nature, we muſt ever continue ignorant; yet, in ſome reſpects, the ſimilitude is undeniable: (1.) By the revolutions of each globe on its axis, they, like ourſelves, poſſeſs the viciſſitudes of day and night; for what imaginable reaſon, but to diſtinguiſh the periods of labour and repoſe? Like ourſelves they need refreſhment; and to them, as to us, the luſtre of the day, and the tranquillity of the night is grateful. (2.) Providence has kindly furniſhed them with numerous ſubſtitutes for the ſun, that their night may never know the melancholy of total darkneſs, and may often be enlightened by ſeveral attendant ſatellites at once: does this imply, that ſome ceaſe not their ſtudious contemplations, but as well by night

night as by day, prolong their reſearches into knowledge and ſcience? Or, is this favouring diſtinction diverted by avarice to ſerve its ſordid purpoſes? to whoſe ardent purſuit of wealth the day is too ſhort, and who includes in his graſp the additional hours of night. It is probable, I ſay, they have among them buſy ſpirits to whom the day is inſufficient, who add ſtore to ſtore, whether of wealth or knowledge, whether of fame or of power. When acquired, do they retain it?—Perhaps, like us—they die. This I think certain: attendant ſatellites are uſeleſs to a barren planet. (3.) They have alſo a variety of ſeaſons; in Venus very conſiderable; in Jupiter, ſcarce ſenſible as to length of day and night, but probably very different as to rain, &c. (4.) They have alſo ſea and land; for thus we account for their ſpots; the bright ones are mountains, the dark ones waters; and much as our Atlantic Ocean, with a large iſland in it, might appear to them, are ſome of their appearances to us.

Shall I be permitted to trace a kind of connection (an imaginary kind of connection I allow) which circulates around us: two perſons who dwell in the ſame ſtreet, though perhaps not intimate, yet if they meet at the further end of the town, they acknowledge each other as neighbours: two townſmen, at an extremity of the kingdom, conſider each other as fellow-citizens. In ſome foreign European ſtate, two Engliſhmen are ſocial as compatriots; to Europeans in China, diſtinction of nation ceaſes. So might we imagine inhabitants of this globe (chooſe what extremes you will), removed to Jupiter or to Saturn, they would probably loſe the idea of their original

ginal diſtance, and claim kindred as fellow-globeſmen. Fancy may carry the idea yet further, and ſuppoſe in ſome remote fixed ſtar, a meeting of natives of the earth, of Jupiter, of Saturn, would they not aſſociate by planetary connection, and urge as a reaſon,—why, he belongs to our ſyſtem? How extenſive in the human heart is the principle of ſelf! our ſyſtem!

The various proviſions made by our common Author for the well-being of his various works, ſhould excite not only our eſteem, but alſo our dependance and truſt. Infinite Wiſdom neither with-holds, nor waſtes its efforts. To a planet ſo near the ſun as Mercury, its portion of ſolar light is abundantly adequate to every want of its inhabitants, inſomuch, that probably, its abundance is moderated. Mercury therefore requires no moon, it would be ſuperfluous; but let inhabitants of earth accept with thankfulneſs the ſervices of that lucid orb which waits on them, which diſſipates the obſcurity of night, and "ſhadowy ſets off the face of things." Planets more diſtant from the ſolar fire, enjoy yet greater attention; four moons, inſtead of one; or if four be inſufficient, behold a vaſt ring of light; an atmoſphere of luſtre!

When I have heard the diſpenſations of Providence arraigned, how have I wiſhed that ſuch perſons had reflected on the conſtitution of things! What! vain man, wouldſt thou diſplace the appointments of Omniſcience; or, art thou diſcontented with his diſpoſal of *thee?* Then let thy ſagacity control the ordinances of Heaven, deprive Jupiter of his ſatellites, and beſtow them on Venus; diveſt Saturn of his ap-

pendage, and ornament Mercury with his belt. You fret and fume that other planets ſhould abound in lunar attendants, while we have but one! We have but one moon, it is true, but by how much are we nearer the ſun? The uſual cauſe of diſcontent, is inattention to both ſides of our condition; did we ſee rightly our own advantages, and were we acquainted with the draw-backs on our neighbour's apparent happineſs, envy and diſcontent would nearly vaniſh.

Methinks the principle may bear a little enforcing—the great among mankind are like Mercury, always in ſplendor and brilliancy; but how would inhabitants of earth bear ſuch extreme luſtre? it would probably require peculiar conformation of our viſual organs, and would quickly excite ardent wiſhes for a more moderate ſun, for the ſerene and peaceful walk by moon-light. Happy thoſe

Far from the madding crowd's ignoble ſtrife,
Whoſe ſober wiſhes never learned to ſtray,
Along the cool ſequeſtered vale of life,
Who keep the modeſt tenor of their way.——

A word or two, if you pleaſe, on the names formerly given to the planets; which differed in various nations of the earth. The ſun, as the moſt glorious of the heavenly bodies, was named by the Phœnicians *Beelſamen*, the Lord of Heaven, and is undoubtedly the *Baal* of the Scriptures: his common Greek name *Helios*, is thought to be derived from the Hebrew, *Al*, one of the names of God: his moſt ancient Hebrew name is *Shemeſh*, a ſervant, *i. e.* a ſervant—of the Creator—to the creation.

tion. The moon is called in Greek, *Selene*; in Latin, *Luna*; both implying light. Her Hebrew name, *Lebanah*, is from her whiteneſs; beſide which, ſhe is called by a name, which ſignifies to refreſh.—Mercury was called *Stilbon*, ſhining, from his vivid luſtre; Venus, *Eoſphoros*, the morning ſtar; *Phoſphoros*, the harbinger of light, when ſhe riſes in a morning before the ſun: *Heſperos*, when ſeen after him in the evening. Mars was termed *Pyrois*, fiery, from his reddiſh appearance, which moſt, if not all nations, have noticed. Jupiter was called *Phaeton*, brilliant; his ancient Hebrew name is thought to have been *Gad*: Saturn is in Greek, *Cronos*, time, hinting at the length of his period. In Hebrew, *Khiun*. It is clear from hence, that theſe planets were not originally regarded as deities, or conſidered as reſidences of ſupernatural powers; but by degrees, as idolatry became general, the memorials of great princes who were men of renown, were transferred to their cuſtody, and theſe ſtars were dedicated to them reſpectively.

It is curious to trace the progreſs of idolatry; of which Zabiiſm, or the worſhip of the Hoſt of Heaven, is certainly the moſt ancient branch. We have already noticed its prevalence with regard to the ſun, whoſe invigorating influences ſeem to have given ſome kind of ſupport to the practice, eſpecially, as we may ſuppoſe it to have been introduced at firſt, in the form of ſimple ſalutation.

The moon ſeems next to have engaged the ſuperſtition of mankind very naturally.

Without offering the leaſt vindication of the abſurd impieties

of former ages, let us reflect, for a minute or two, on the probable courſe of this error with regard to the planets. Aſtronomy ſeems to have been earlieſt known in the Eaſt, where alſo idolatry originated; the viciſſitude in the aſpect of heaven was there quickly noticed, through a ſerene air, clear and tranſparent. Add to this, that the ardent heats of day were almoſt inſupportable, and evening and night were times of enjoyment. To thoſe therefore who looked forward to the cloſe of the ſultry hours, who hoped for free reſpiration in the cool of the evening, nothing could be a greater pleaſure than the riſe of that ſtar which indicated its approach; nothing could afford a ſubject of more general gratulation: moreover, as the inhabitants of theſe countries ſlept in the open air, on the houſe-tops, &c. they ſoon contracted an acquaintance with the ſtars, gave them names, perhaps had their favourites, admired their brightneſs, obſerved their affairs went well when ſuch a ſtar appeared, then fancied its influences, and glided into——idolatry. For let it not be ſuppoſed that the human mind could ſuddenly fall into ſo ſhocking an abſurdity: vice muſt enter by degrees, put on firſt fair appearances, aſſume a pleaſing guiſe, become an angel of light; then, gradually, ſtep by ſtep, gently, without alarm, without a ſhock, decline into its native track: but, when by habit, it has gained familiarity, and force by cuſtom; who ſhall limit its exceſſes? Let therefore my auditory remember, that even idolatry had at firſt much to recommend it, and the commencement was not apparently connected with the cloſe.

I could heartily wiſh there exiſted among us no remains of

ſuch ideal influences of the ſtars; we ſhould then no longer be peſtered with predictors and fortune-tellers, and every conjuror might be *tranſported* as he deſerved. The natural influences indeed of the ſun, I allow; they are many, and powerful; thoſe of the moon are conſiderable, and undeniable. Thoſe of the planets are by far too trivial on the whole globe, to have any effect on the fate of individuals, to rule particular parts of the body, or to dominate over ſuch or ſuch regions of the human frame. We have indeed been told, that

When weak women go aſtray,
The ſtars are more in fault than they.——

And we ſometimes hear a ſimpleton conſole himſelf under a miſchief, that "it was his ill ſtars, how could he help it?" But we have ſeen this evening, LADIES and GENTLEMEN, that thoſe of the ſtars, whoſe power may be ſuppoſed ſtrongeſt, have buſineſs of their own to mind, and whether hot, or cold, moiſt, or dry (of which we know nothing), they engage their qualities in the ſervice of their own inhabitants.

Without dependance on the ſtars, or fear of their malignity, let us employ our talents as rational and immortal beings, who are to be applauded or condemned by their own behaviour; let us remember, that as he who is found ultimately a wiſe man, will not be deprived of the reward of his wiſdom, under the plea, that he was indebted for it to the ſtars; ſo the fool ſhall ſuffer for his folly, nor will it be deemed his juſtification, that he thought his fate inevitable, his ill-luck! his

ill-

ill-ſtars! Let him lament his inattention, not the aſpects of the Heavens; his ignorance, and inconſiderateneſs, his levity, and abſence of mind; theſe are his real (but not unavoidable) diſaſters.

*** Since this Lecture was compoſed, it is underſtood that Mr. HERSCHELL has diſcovered *two*, if not more, ſatellites revolving round the Georgian planet; it is probable that more may hereafter be aſcertained; as it ſeems likely, that ſome advantages of conſtruction in itſelf, or ariſing from its attendants, compenſate for its ſo much greater diſtance than Saturn from the fountain of light.——*N. B.* The difference of light ariſing from the diſtances of the planets from the ſun, is probably much leſs than is occaſioned by the change of ſeaſons on the earth; ſo that if Mercury be eſtimated at the brilliancy of a ſummer's noon, Saturn, and the Georgian, may be thought at leaſt equal to a cloudy or hazy day, conſequently they have light amply ſufficient for all the purpoſes of life, ſuppoſing their atmoſpheres to be ſimilar to ours: but that they may be varied ſuitably to ſituation, admits not of doubt.

OBSERVA-

OBSERVATIONS on the PLATES

Belonging to LECTURE V.

PLATE I. HARVEST MOON.

FIG. 1. The courſe of the moon varying from that of the ecliptic (5°), and the ecliptic varying no leſs than twice 23° 30′ at one ſeaſon than at another, it is natural to infer, that the moon's appearances muſt be affected with correſpondent diverſity. This figure is to be ſuppoſed a view of the eaſtern hemiſphere of the heavens, in which, by the rotation of the earth, the moon riſes (on the horizon H of a ſpectator) parallel to ſuch rotation: now, according to the obliquity of the moon's courſe, ſhe will come to the horizon ſooner, or later; for example, if her courſe be in the direction A, *f*, and laſt night at ſix o'clock ſhe roſe at ♈ (in the equator), ſhe will to-night riſe at *g*, from which *f* being but little diſtant, ſhe will be but little later than laſt night: but if her courſe was from A to *a*, it is clear, that though laſt night ſhe roſe at 6 o'clock in ♈, yet to-night it will be much later ere ſhe reaches the horizon in *h*. Every night the moon, by her ordinary courſe round the earth, riſes later and later 13°.

As this ſubject is curious, and conſtant every year, more or leſs, yet not much underſtood, we offer ſeveral figures for further elucidation.

Throughout theſe figures, H H is the line of the horizon, E Q the equator, P *p* lines parallel to the equator, N the north pole of the heavens, S the ſouth pole.

Firſt, we wiſh to conſider the different ſituations of the ecliptic itſelf, in different ſeaſons of the year, ſuppoſing the moon actually in the ecliptic: next, to add ſuch deviation of the moon from the ecliptic, as correſponds to her actual track.

Fig. 2. The ecliptic (♋♈) in its higheſt poſſible ſtation; the track of the moon ABCD, conſequently ſhe is carried *deeply* under the horizon daily; and to riſe on the line H, requires a much longer time every night. As, if ſhe roſe at 6 o'clock at B laſt night, ſhe will at ſix o'clock to-night be at C, conſequently will have the conſiderable interval C*f* to paſs over, ere ſhe can appear at the horizon: moreover, as ſhe declines towards the ſouth pole S, ſhe will be longer and longer every night ere ſhe is viſible to any northern horizon. This, therefore, is the leaſt favourable ſituation of the ecliptic for a harveſt moon in the northern hemiſphere.

Fig. 3. Is the reverſe of the former figure: the ecliptic (♋♈) being very low, and the courſe of the moon ABCD, tending toward the north; ſo that from C to *f*, is now a very ſhort diſtance on the parallel P p. So that if at ſix o'clock yeſterday ſhe roſe at B, it will be not many minutes after ſix to-night ere ſhe riſes at *f*.

Fig. 4. Repreſents a more northerly latitude than England, and is among the ſtrongeſt proofs of the beneficial variety of the moon's motion; as in this ſuppoſed latitude (66°, 30′) the horizon coincides with the ecliptic, the moon will be ready to riſe upon the horizon, for ſeveral evenings together, A B C D, long before the twilight is withdrawn, if not immediately as the ſun declines.

We have only to add the idea, that ſhe is now full, and we ſee how beneficial her early riſing is, eſpecially if it happen

happen at that ſeaſon of the year (autumn for inſtance) when her light is moſt wanted (becauſe of the important buſineſs ſhe contributes to prolong), and when the ſun is not longeſt above the horizon. The ſuppoſition of her being at full, implies her oppoſition; conſequently ſhe is ready to riſe as the ſun is about to ſet in the oppoſite part of the heavens.

This is the favourable ſituation of the ecliptic about the end of Auguſt and beginning of September.

Fig. 5. In fig. 2 and 3, we conſidered the courſe of the moon as coincident with the ecliptic; but as her courſe really differs 5° from it, we muſt now add thoſe 5°, in order to attain a juſt idea of her variation. In this figure, it appears that her declination is yet more ſouthward than in fig. 2. by 5°, conſequently, any given point (as C D) on her courſe, is, by that addition, yet further from riſing early on the horizon (in the north), than the ecliptic itſelf (♋♍).

In fig. 6, the 5° which in the former figure were injurious to the northern horizon (and beneficial to the ſouthern, where they are by very much moſt wanted at this time), now contribute greatly to her early appearance to us; C and D being little below the horizon, and the moon in thoſe ſtations having little diſtance to advance ere we perceive her refulgence.

The intervals between the letters ABCD, &c. are greater in theſe figures than in fact: to render the principle illuſtrated more ſenſible to the reader.

PLATE

PLATE II.

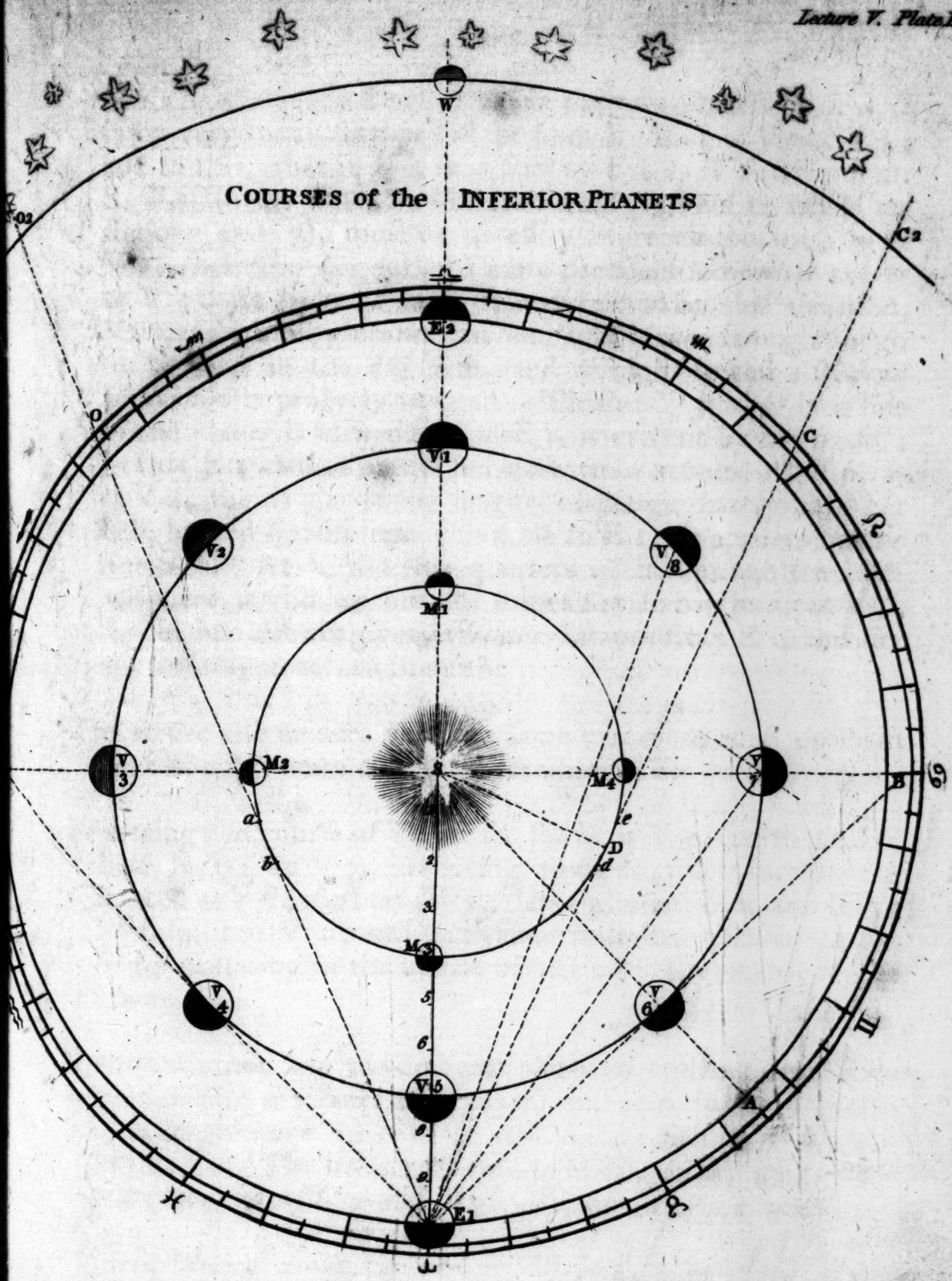
COURSES OF THE INFERIOR PLANETS.

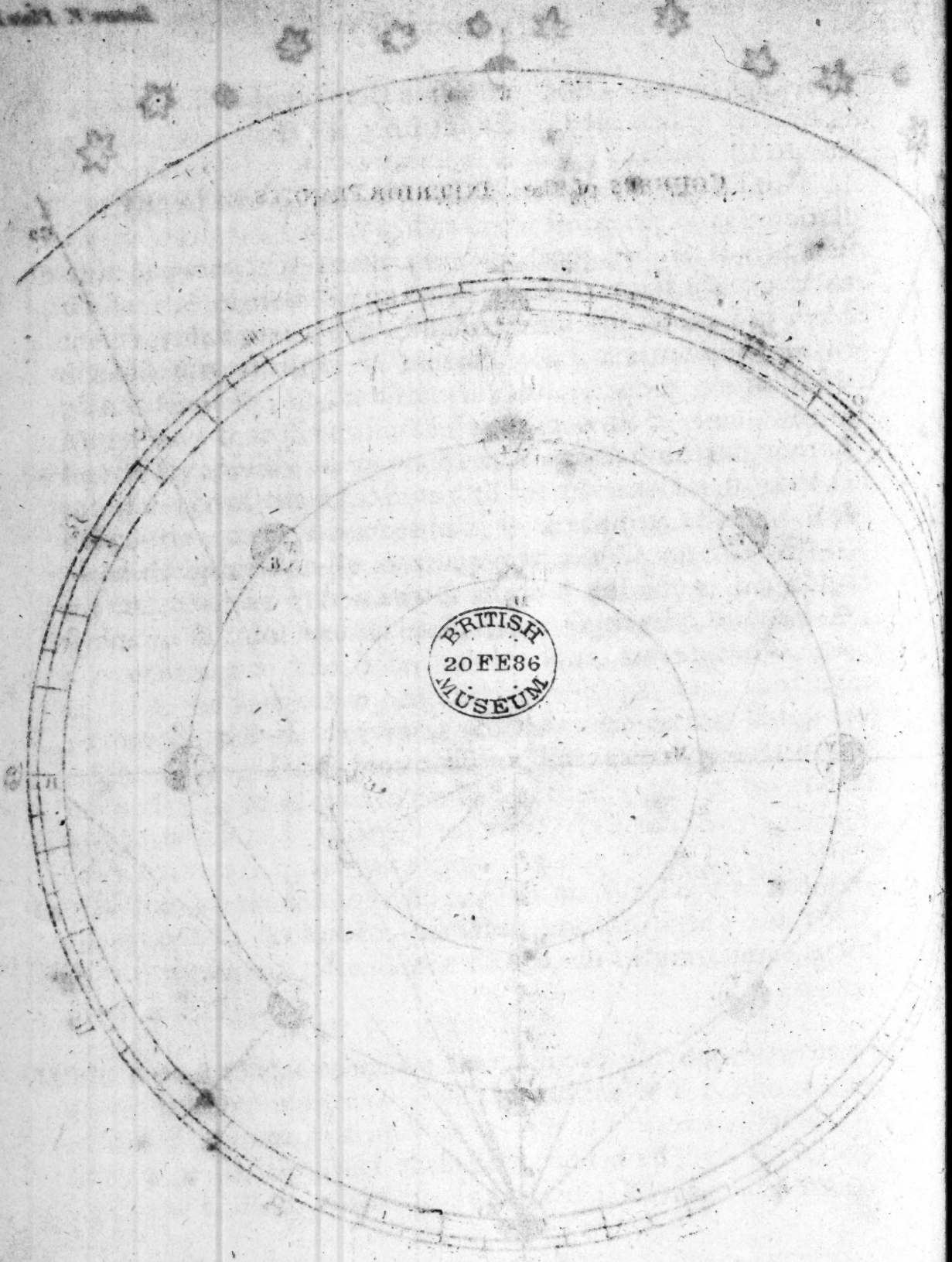
In this diagram, the earth (E 1) is ſuppoſed to be at reſt, while the planets Venus (V) and Mercury (M) perform their revolutions. The diſtance from the ſun (S) to E 1 is divided into ten parts, as hinted p. 64; at the fourth part is placed Mercury, at the ſeventh Venus. To begin with M: M 1 ſhews that planet in conjunction with S, from whence he rapidly advances towards M 2, where he is diſtant from any interference of the ſolar rays; ſo far he appears DIRECT in his courſe: as he advances to *a*, his pace ſlackens, and from *a* to *b* though he really moves, yet to E 1 he appears without motion, *i. e.* STATIONARY: from *b* to M 3, his courſe ſeems to E 1 to return back, from ☌ toward ♏, and ♐; *i. e.* contrary to the order of the ſigns, or RETROGRADE: at M 3, he is again in conjunction with S, and continues retrograde till he arrives at *d*; here he ſeems ſtationary while moving from *d* to *e*; where he again becomes direct in motion to M 4, and ſo continues to the end of his courſe in M 1.

In the ſame manner V 1, V 2, V 3, to V 4, is direct in motion; at V 4 ſtationary, (in ♍ among the ſigns) from V 4 to V 6 retrograde, ſtationary at V 6, and from thence again direct.

With regard to the more or leſs enlightened appearances of theſe planets, it is extremely clear, that at V 1, the whole of the illuminated part of the planet is turned towards E 1, but the ſuperior blaze of light tranſmitted by S, entirely precludes and drowns its brightneſs. At V 2, though much of

COURSES of the INFERIOR PLANETS





of its light reaches E 1, yet beſide the neighbourhood of S, it is by very much further diſtant from E 1 than in V 3 or V 4; add to this, that in V 4 it is ſeen by E 1 as if further from S, than in any other ſtation (and a line drawn to any other ſtation (as V 7), muſt of neceſſity approach toward S); at V 4, therefore (or perhaps more preciſely ſomewhat nearer to V 5), its light is moſt ſplendid; and in this ſituation, Venus is a moſt glorious ſtar, her light is even ſtrong enough to be ſeen in the day-time, and at night to caſt a ſhadow from objects properly ſituated. That at V 5, the dark ſide of the planet is turned toward E 1, is evident by the figure; ſo that E 1 cannot expect her now to be viſible. At V 6, as at V 4, ſhe is extremely bright, although barely half her enlightened hemiſphere be viſible to E 1, as appears by the line S A. At V 7, three quarters of her enlightened hemiſphere is viſible; but ſhe ſhines not ſo bright as at V 6, for reaſons already given, viz. her diſtance from E 1, and her apparent approach to S.

The figure alſo evinces that the ſame variations muſt occur in M, although more clearly diſcernible in V.

In tracing the courſe of V, we ſee ſhe is at V 5, dark: at V 6, half light; at V 7, advancing towards full; further advanced at V 8; full at V 1; leſs light at V 2, and V 3; half light at V 4; and decreaſing in light, till ſhe reaches V 5; imitating in the courſe of her orbit the phaſes of the moon.

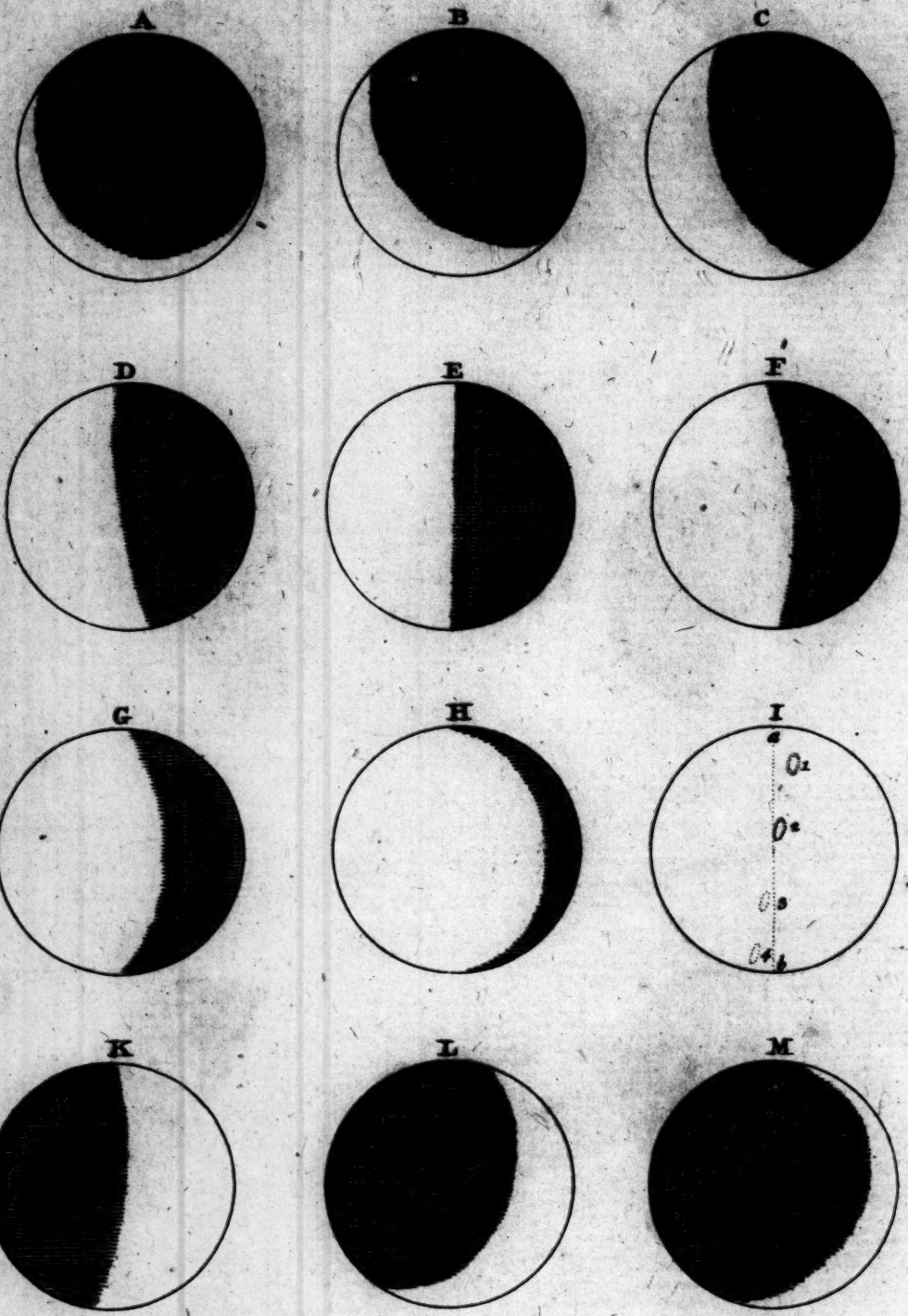
It is worth noticing the different places of a planet ſeen from the ſun (*i. e.* its *heliocentric* place) and ſeen from the earth (*i. e.* its *geocentric* place): as at V 6, the firſt is S A; the latter, E B. The heliocentric place of M 4 is B; its geocentric place nearly C; and ſo of others.

As a proof of the truth of these principles, it remains to remark the apparent bulk of these objects, as seen from E 1: for it is evident, that V 1 is so very much further distant from E 1 than V 5 is, that she ought not to be of equal dimensions: and this is the fact; V 5 being largest of all, and the planet decreasing in magnitude as she approaches V 1, where she is smallest. This reasoning may also be inverted; if V 1 is so much smaller than V 5, her diminution proves she is further distant; if she is further distant, smaller, full enlightened, and also in conjunction with S, it demonstrates that her course is round S, and that it cannot possibly be round E, or round any other centre than S. The same reasoning applies to M.

This plate also hints at a similar appearance of the planet MARS (W). When the earth is at E 1, it sees W all across the system; a distance very remote indeed! consequently we may expect to find him small: but when the earth in her course arrives at E 2, W is by much larger and brighter. The foregoing reasoning applied to this article, proves that Mars circulates round S; and by consequence the other planets also.

AS

VIEWS of VENUS.



Lecture V. Plate

ECLIPSES of JUPITER'S MOONS, *and* VELOCITY of LIGHT.

Fig. 2

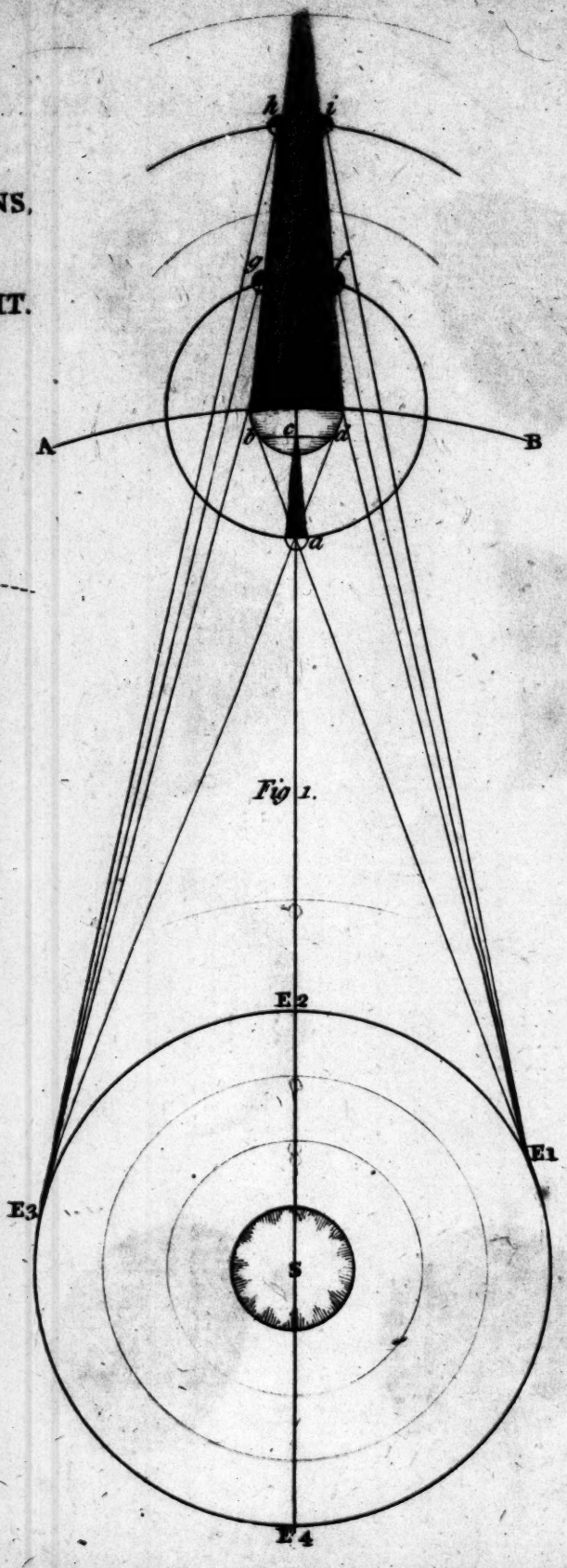
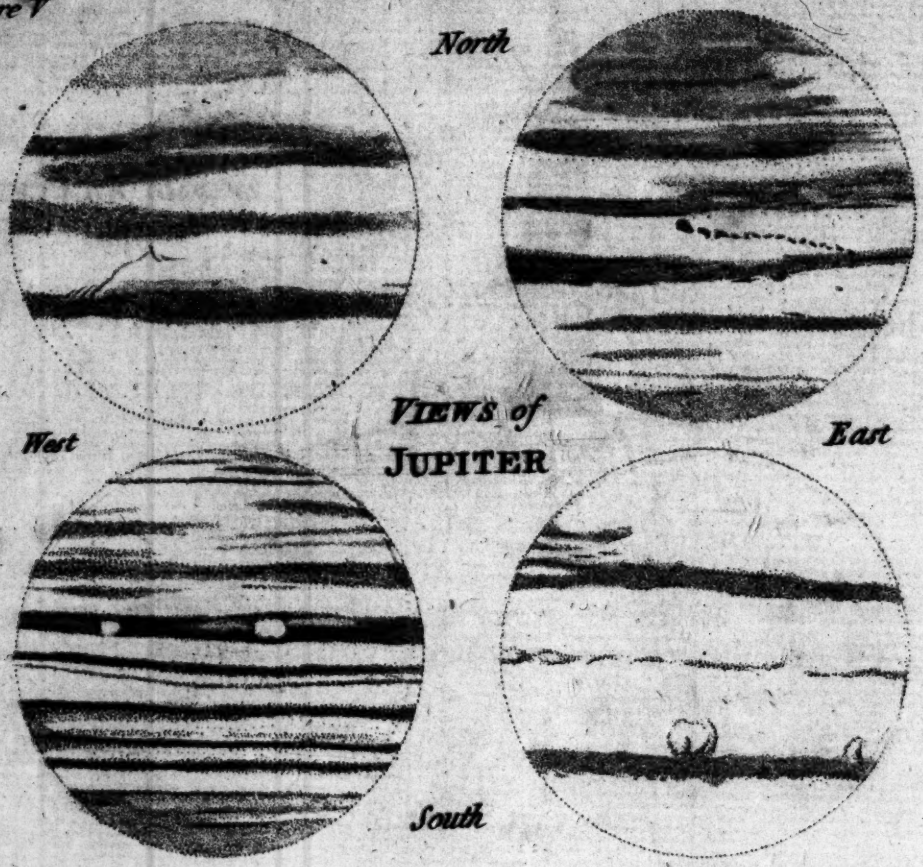


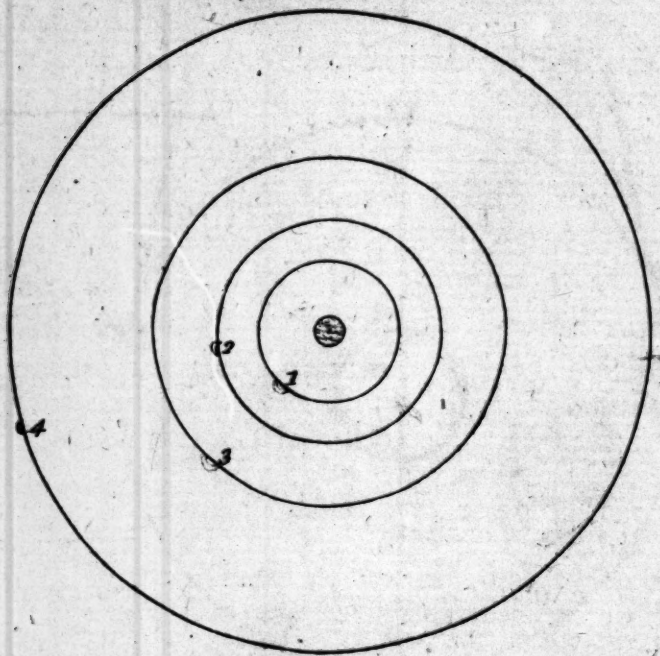
Fig 1.

Lecture V
Plate



VIEWS of
JUPITER

Plan of Jupiter's System of Moons.



AS ocular demonſtration ſupports theſe principles, plates III. and IV. are copied from HEVELIUS the aſtronomer, who drew them from the planets themſelves ſeen in their courſes.

VIEWS OF MERCURY. (Plate III.)

A Is the planet M advanced a little from M 3; B and C, about M 4; DEF (the enlightened ſide *reverſed*), about M 2.

VIEWS OF VENUS. (Plate IV.)

Theſe twelve views exhibit a complete courſe of this planet: ABC in her progreſs between V 5, and V 6; D, at V 6; EF, between V 6 and V 7; G, at V 7; H, at V 8; I, at V 1; K, about V 4; L and M, advancing to V 5: the light ſide is reverſed in the three laſt letters. Fig. C may be conſidered as that phaſe of Venus, when her light is actually moſt brilliant ſeen from the earth.

N. B. Theſe figures are all ſtruck of the ſame dimenſions; it was thought unneceſſary to vary their ſizes, as it needs no proof that diſtance decreaſes them.

Fig. I being void, we have taken the opportunity to ſhew the courſe of this planet's rotation: *a b*, the perpendicular; 1 2 3 4, a ſpot ſeen traverſing her ſurface; 1 and 2, the ſame ſpot advanced, actually ſeen by *Caſſini* in one morning; 3 and 4, inſerted by implication, to complete the rotation; which appears to be within about ſeven degrees from the perpendicular.

PLATE V.

COURSES OF THE SUPERIOR PLANETS.

Fig. 1. Repreſents the appearances of the planet Mars (M), as ſuppoſed to be at reſt while (E) the Earth performs one revolution, conformable to the idea ſuggeſted in the Lecture, p. 89. E 1, will ſee M among the firmament of ſtars at *a*; as E advances to E 2, M advances to *b*; and from E 3, appears at *c*; where he is ſtationary ſo long as the courſe of E is (as a little before E 3, and a little after E 6) nearly coincident with a ſtraight line; but as E moves forward to E 4, M moves backward from *c* to *b*; between E 4 and E 5, M is ſeen in *a*, ſtill going backward: at E 5 he is removed to *d*; at E 6, to *e*; from E 6 to E 7 he ſeems again to be direct in motion; advances to *d*; and from thence to *a* again. The extremes of the earth's orbit are the places where the planet M appears ſtationary; while E is in its further ſemicircle, M ſeems direct; when E is in its neareſt ſemicircle, M ſeems retrograde.

Fig. 2. The former figure ſuppoſed (contrary to fact) the object to be fixed; but in this figure, both bodies are ſuppoſed in motion. It is clear, that if Jupiter takes twelve years to complete a circle round the ſun, one-twelfth part of a circle will repreſent one year's progreſs: during which period, the earth completes a whole revolution. Let therefore the ſmall circle repreſent the orbit of the earth; and the part of a circle above it, marked 1 to 12, repreſents one yearly part of the orbit of Jupiter. Divide earth's orbit into twelve parts (*abcdefghiklm*), each one month; divide alſo the portion of Jupiter's orbit into twelve parts (1 2 3 4 5 6 7 8 9 10 11 12) each one month alſo; and ſuppoſe Jupiter

COURSES of the SUPERIOR PLANETS.

Fig. 3.

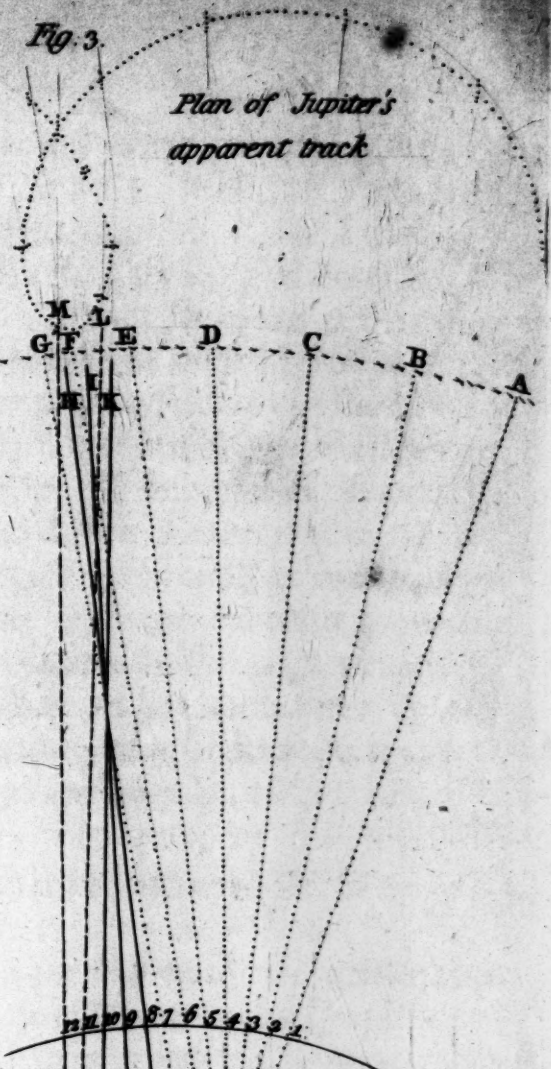
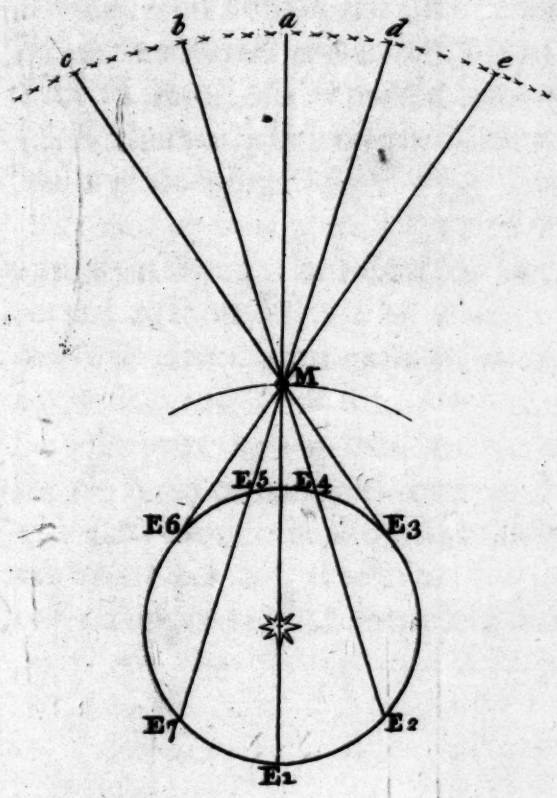


Fig. 2.

Fig. 1.



piter to be ſeen as he really would be, among the ſtars of the firmament. Trace the line *a* to 1, the firſt ſtation of Jupiter, ſeen in A; trace alſo *b* through 2 to B, *c* through 3 to C, *d* through 4 to D, *e* through 5 to E, *f* through 6 to F, *g* through 7 to G; ſo far the planet ſeems direct in motion; but every monthly interval leſſens from the foregoing, conſequently the motion of the planet ſeems conſtantly to be retarded (hitherto on the plate the times are marked in ſmall dots); from *h* through 8 to H, the planet ſeems to return; from *i* alſo through 9 to I, the planet is retrograde, and alſo from *k* through 10 to K (theſe lines are drawn ſtrong, and continued on the plate); from *l* through 11 to L, is ſeen a ſmall advance in his courſe; *m* through 12 brings him to M, from whence he is ready to begin another courſe (A B C, &c.), being direct in motion (theſe lines are marked in long dots).

To explain fig. 3. we need only remark, that while the earth in the firſt part of her courſe is really going *from* Jupiter, Jupiter *ſeems* to recede from the earth; and the more the earth increaſes her diſtance, the further off ſeems Jupiter to travel; but when the earth advances toward Jupiter, he ſeems to approach nearer; and to recede again as the earth's progreſs increaſes the interval between them. Such is his apparent annual track as ſeen from the earth; and twelve ſuch annual tracks complete his orbit.

PLATE

PLATE VI.

VIEWS of JUPITER.

THESE are given to ſhew the appearances ſeen on the body of this planet through a teleſcope, and called his belts. Sometimes they ſeem as if united into breadth; ſometimes tranſverſe ſpots ſeem to form a communication between belt and belt; ſometimes they ſeem more diſtinct, and in lines, and ſhew bright ſpots; and ſometimes, but rarely, they ſeem almoſt diſſipated. Whether they are extremely denſe clouds, and the bright ſpots mountain tops ſeen above them; or whether they are waters impelled very fiercely by the rapid motion of the planet's rotation, or attracted into tides by his moons, may be rather conjectured than determined.

PLAN of JUPITER's SYSTEM of MOONS.

THESE are drawn according to the diſtances mentioned in the Lecture, p. 68; and are marked as they are uſually denominated, beginning with that neareſt to the planet.

PLATE VII.

ECLIPSES of JUPITER's MOONS and VELOCITY of LIGHT.

IN this figure S is the ſun, E 1, E 2, E 3, E 4, the orbit of the earth, AB the orbit of Jupiter, *a* Jupiter's firſt ſatellite ſeen caſting a ſhadow *(b c d)* on its primary, *f g* the ſame ſatellite ſuppoſed eclipſed by its primary. Upon which we obſerve, that *a*, ſeen from E 1, ſeems to follow its ſhadow *(b c d)* falling on Jupiter, being eaſtward of it, ſo that it ſeems juſt to touch the diſk of the planet when its ſhadow is at leaſt paſſed half way over it; and before the ſatellite is advanced to the middle of Jupiter, the ſhadow will be gone off at *d*: but if *a* be ſeen from E 3, it will appear to go before its ſhadow, and will be paſſing off the diſk of its primary at *d*, while its ſhadow yet appears at *c*. On a ſimilar principle the immerſion of *f* into the ſhadow of Jupiter, is diſcerned from E 1; but its emerſion or exit from the ſhadow, cannot be ſeen, being concealed by the body of the planet: whereas at E 3, its emerſion only is viſible, and its entrance into the ſhadow is hidden. This is regularly the caſe of the firſt ſatellite, and generally alſo of the ſecond; but the third ſhews frequently both its immerſion and emerſion, as *i h*, the entrance *i* is viſible, both from E 1 and from E 3: as alſo is the exit *h*. As to the fourth ſatellite, it is ſo far from Jupiter, that Jupiter's ſhadow is much diminiſhed ere it reaches it; by which, together with the inclination of its orbit to that of its primary, it ſeldom

is eclipſed, but paſſes above the ſhadow; or ſometimes, it ſuffers a partial eclipſe, as in fig. 2, in which remarkable ſituation it was ſeen by CASSINI.

It is proper to obſerve, that the ſatellites vary in their appearances, ſometimes paſſing over the body of Jupiter as dark ſpots, ſometimes bright like himſelf; this renders it probable that theſe ſatellites have a rotation, each on his proper axis, whereby ſometimes that part of a ſatellite which is leaſt fitted to reflect light (ſpotted perhaps with land and water) is turned towards us, at other times we ſee that ſide moſt fitted to reflect light. This alſo varies the brightneſs of theſe moons: the fourth, which is generally the leaſt, is ſometimes the largeſt of all; the third, which is uſually largeſt, is ſometimes leaſt; and ſo of the others.

The ſize of the ſatellites is about half a diameter of the earth; the third rather larger. CASSINI ſuſpected the firſt ſatellite to have an atmoſphere; becauſe the ſhadow of it could not be ſeen, when he was ſure it ſhould have been on the diſk of Jupiter, if it had not been ſhortened (like the ſhadow of our earth) by an atmoſphere.

We are beholden to theſe ſatellites, for the firſt proof that the paſſage of light is not *inſtantaneous*; but though extremely rapid, yet that it takes *ſome* time in paſſing from one place to another: thus, while E 4 is advancing towards E 1 (nearer to Jupiter), the immerſions more and more *anticipate* their true times, as calculated by their juſt theory; whereas while E 3 is going to E 4, the emerſions appear later and later. The diſtance is ſtill greater between E 4 and E 2, and makes a difference of ſixteen minutes *later*, to E 4; *ſooner* to E 2: how is this variation to be accounted for? or what conſumes

ſixteen

ſixteen minutes of time? the motions of theſe bodies are doubtleſs exactly regular: ſimply, in fact, the difference of the diameter of the earth's orbit; in traverſing which, the light conſumes ſo many minutes. The firſt ray from an emerging ſatellite, is like a meſſenger ſent to relate the news; if we advance to meet him, we by ſo much anticipate the time of his telling his tale; but if we retire further from the place whence he is diſpatched, he muſt needs take additional time to follow us.

The principle to be drawn from this fact, is, that as we ſee the heavenly bodies only by their light, and that light has taken ſome time in the paſſage to us; ſo during that time the luminary has continued its progreſs, and is not *now* in the very identical ſpot it occupied when its light was emitted, and ſent to our eyes: thus the ſun is perhaps ſeven or eight minutes farther advanced in his daily courſe than we ſee him to be, and a fixed ſtar diſpatched towards us thoſe rays by which we now ſee it, perhaps not only months, but years ago; which time is conſumed in the paſſage of its rays through an interval ſo aſtoniſhing.

The principle adopted for finding the longitude, by means of the ſatellites of Jupiter, is, by tables calculated for any certain meridian (as that of London) ſhewing their exact ſtation at any certain hour of the day (as nine o'clock in the evening). By obſerving, in Jamaica, for inſtance, the preciſe time when the ſatellites preſent the ſame poſition to a ſpectator there, is found, the difference of TIME between that place and London; which is eaſily turned into degrees and minutes, allowing 15° to the hour.

PLATE VIII.

PERSPECTIVE VIEW OF THE ORBIT OF SATURN DURING HIS COURSE.

THE peculiarities of this planet's appearance, arise chiefly from the changing form of that appendage termed his RING; which, although it does not vary in itself, but always maintains the same local station, yet presents to our view a regular mutation and diversity. In this view the smaller letters *a b c d*, &c. represent the planet and his ring, supposed to be seen by a spectator placed at a proper distance, during one revolution. The larger letters A B C D, &c. shew the figure of the planet and ring seen from the earth, at corresponding periods. The orbit of the earth is so small in proportion, that the same appearances, very nearly, present themselves to a spectator in the sun.

We observe, that when Saturn is in his ascending node at *a*, the thin edge of the ring (by the bye it is conjectured to be eight hundred miles thick) being turned toward us, we see nothing but a shade on the body of the planet, as at A; at *b* the ring becomes visible, and in this form is (very improperly) termed *Ansæ* (handles); because it happened to be seen in this situation through the first telescope of GALILEO, who being ignorant of its progressive variation, likened it to what it is now found to be totally unlike. At *c*, the ring opens, and continues to widen, till it reaches *e*, from whence it as gradually declines through *f*, *g*, *h*, to *i*, where having fulfilled half a revolution, and being again in its node

Perspective View of the orbit of Saturn during his course.

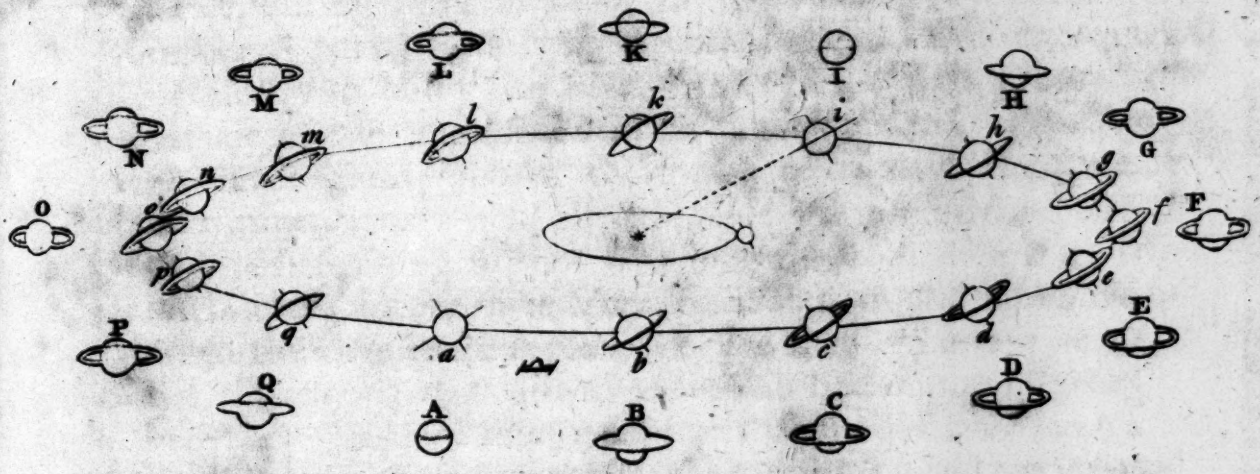
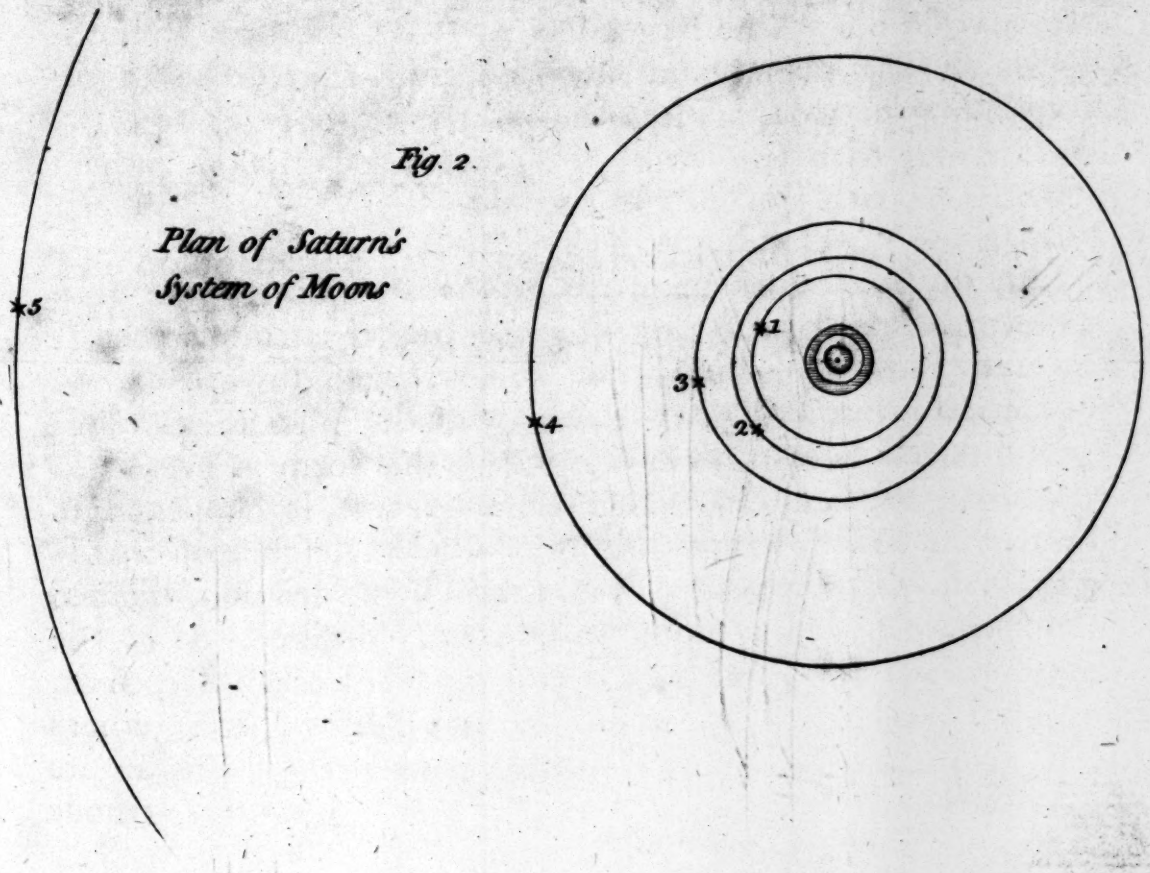


Fig. 2.

Plan of Saturn's System of Moons



node (now deſcending), it is not ſeen. It is clear, that hitherto the upper (or northern) ſurface of the ring is what has been ſeen by us, as alſo by the ſun; conſequently the ſolar light has hitherto viſited only that ſurface: but from *i*, during the remainder of the courſe, the under (or ſouthern) part of the ring becomes viſible, and continues excluſively to enjoy the rays of the ſun. The progreſſive increaſe of the ring to *n*, and its ſubſequent decreaſe, being the exact counterpart of the former ſemi-revolution, needs no comment.

Dr. CLARKE's father once ſaw a fixed ſtar in the interval between the ring and the planet.

FIG. 2. PLAN OF SATURN's SYSTEM OF MOONS.

Theſe are delineated according to the diſtances mentioned p. 68; we know but little concerning them, beſides the periods of their revolutions.

The orbits of the ſatellites coincide with the plane of the ring (*i. e.* about 31° from that of the primary), except the fifth, whoſe orbit inclines only 13° 8′. The orbit of the fourth is eccentric.

PLATE

PLATE IX. VIEWS OF SATURN.

Fig. 1. is a PLAN of Saturn and his ring; ſuppoſed to be looked down on from above. We never can ſee it in this ſituation, but we can ſee ſufficient to verify this repreſentation.

Fig. 2. is, on the contrary, what may be termed an ELEVATION of the planet, as ſeen from the earth; but being in a node, the ring is inviſible, and merely indicated by a ſhade on the body of the planet.

Fig. 3. ſhews the ring very diſtinctly; the ſun illuminating its under ſurface, and caſting a ſhadow upwards.

Fig. 4. is, on the contrary, a diſtinct view of the ring, the ſun illuminating its upper ſurface.

Fig. 5. View of the ring when termed *Anſæ*: the northern or upper ſurface illuminated; the ſhadow caſt downwards, as B. plate VIII. after paſſing the aſcending node.

Fig, 6. The *Anſæ* alſo; the ſouthern ſurface illuminated; the ſhadow caſt upward. As K. plate VIII. after paſſing the deſcending node.

Fig. 7. View of the ring in its extreme height of ſituation, ſeeing the under ſurface. As N. plate VIII.

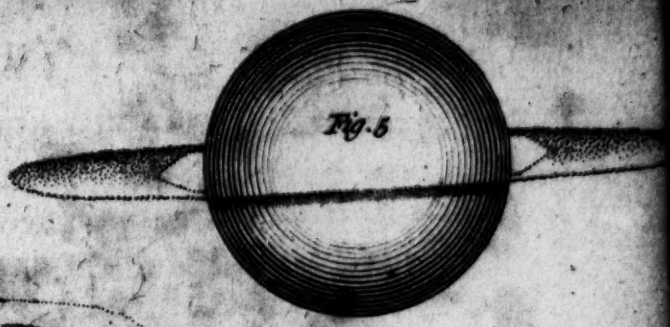
Fig. 8. View of the ring in its extreme height of ſituation, ſeeing the upper ſurface. As E. plate VIII.

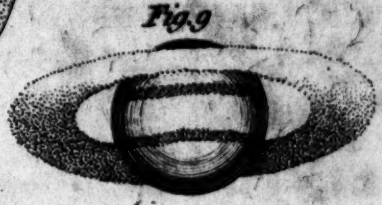
The diviſions, or darker bands on the ring in this view, are what have actually appeared in this ſituation; they have given occaſion to think that the ring is double. It has alſo been ſuggeſted, that the ring has a rotation; but this is not proved, nor perhaps capable of proof, even if it is fact.

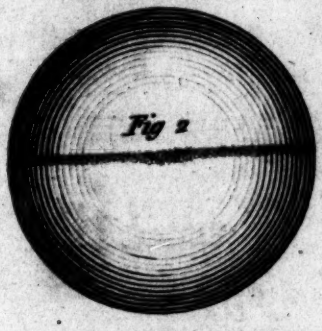
Fig. 9 and 10. are inſerted, to ſhew, that the planet has belts, or ſpots, or bands of ſome kind, on his ſurface: but theſe are not ſufficiently diſtinguiſhed to aſcertain any rotation.

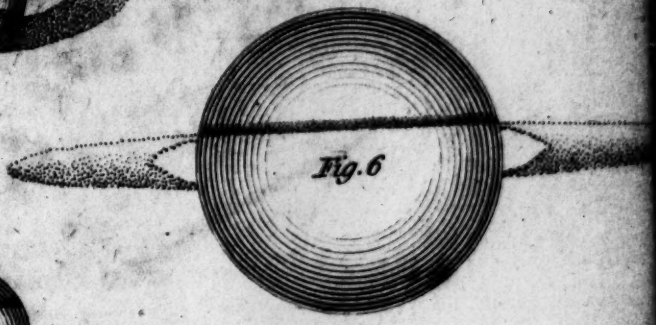
PLATE

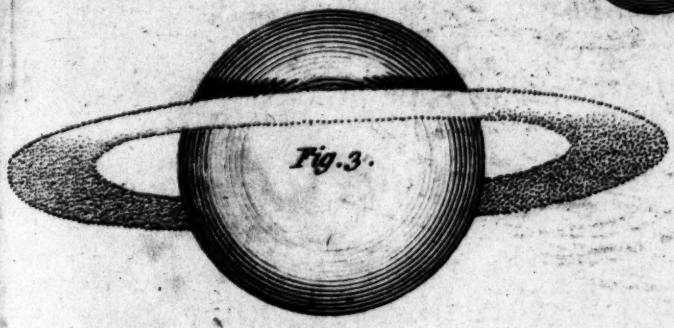
VIEWS of SATURN

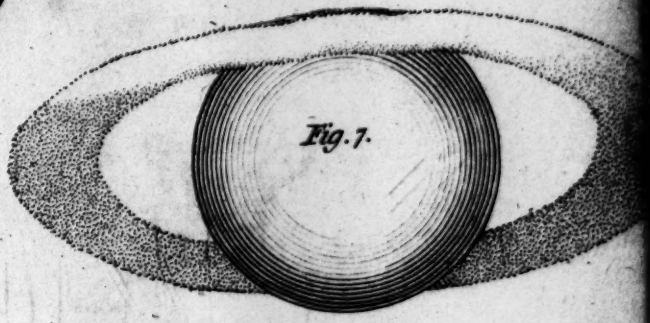


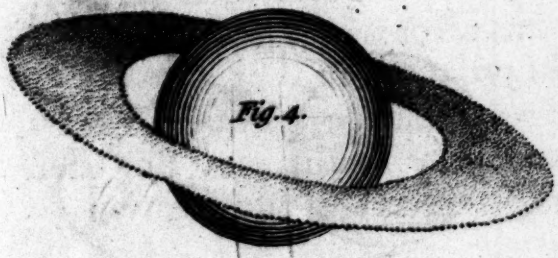


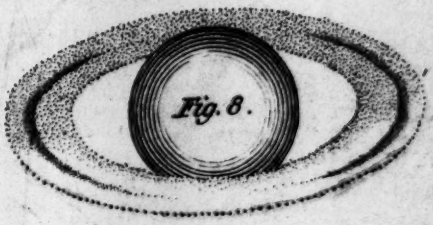












CHARACTERS of the SIGNS.

Aries ♈

Taurus ♉

Gemini ♊

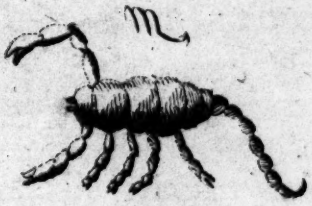
Cancer ♋

Leo ♌

Virgo ♍

Libra ♎

Scorpio ♏



Sagitarius ♐

Capricornus ♑

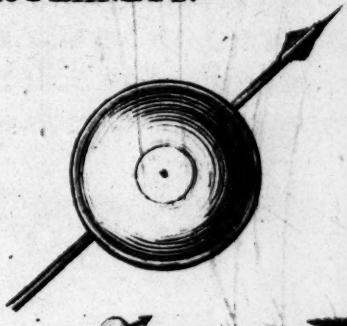
Aquarius ♒

Pisces ♓

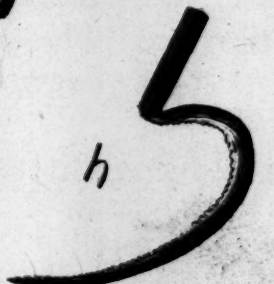
CHARACTERS of the PLANETS.

Mercury ☿

Venus ♀



Mars ♂



Saturn ♄

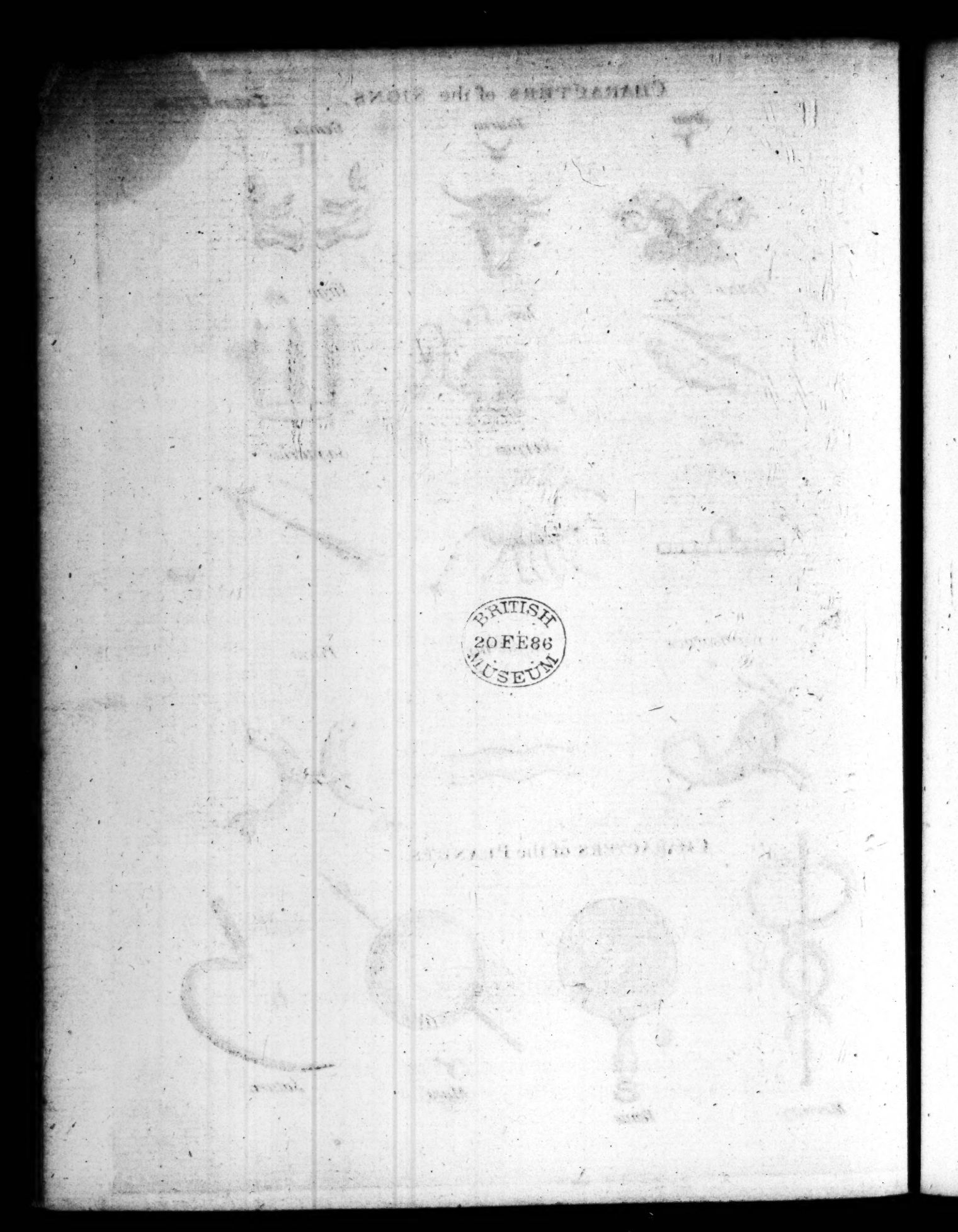


PLATE X.

CHARACTERS of the SIGNS.

THIS plate ſhews the reſemblance of the original repreſentations of the ſigns of the zodiac, to thoſe animals whoſe names they bear: it ſhews alſo their depravation into the characters now uſed, by the haſty copyings of tranſcribers, or unſkilful drawings. The ſigns are always reckoned in the order here placed (correſponding with the Lecture, p. 81.)

(I.) ARIES, the ram's horns, now marked ♈.

(II.) TAURUS, the young bull's head, now marked ♉.

(III.) GEMINI, or the twins: this ſign is ſuppoſed to have been originally the two kids, and is often marked by a character taken from two goats heads butting each other; but as the cuſtom of referring it to the human ſpecies is very ancient (perhaps as the time of deification of Caſtor and Pollux), it is here retained. The mark ♊ is taken from the Grecian ſymbol of thoſe deities. The caps on the heads of theſe boys, are alſo proper to Caſtor and Pollux.

(IV.) CANCER, the crab, is here compoſed of the tail of a crab, or fiſh of that kind, and the head of the Egyptian Ibis. Dr. LONG thinks this character meant originally merely to ſignify the change of the ſun's declination from north to ſouth, by the two lines drawn contrary ways, ♋.

(V.) LEO, the lion's tail, drawn very tolerably reſemblant to its original. ♌.

(VI.) If aſtronomers were ſuch ill draughtſmen as to diſfigure the foregoing ſigns, it is no wonder they omitted the figure of

of VIRGO (the Virgin), and ſubſtituted the three ears of corn tied together, which ſhe held in her hand; we could however have wiſhed, that the current character of this part of this ſign had better expreſſed what it is meant to repreſent ♍.

(VII.) ♎ LIBRA, is clearly the balance.

(VIII.) SCORPIO, is drawn ♏; repreſenting the claws and tail of this animal; as his ſting is in his tail, its dart-like termination could ſcarce fail of diſtinction.

(IX.) SAGITTARIUS, the archer (♐); himſelf omitted, for the ſame reaſon as Virgo, but his arrow inſerted, (ſometimes alſo his bow, or part of it) as more facile.

(X.) CAPRICORNUS, the wild goat; differing pretty much from a tame one, by his hinder part terminating in a fiſh's tail; perhaps this union is not foreign to the occupation of the early nations, (*i. e.* hunting the wild goat, as well as fiſhing) in this month. The firſt character is clearly derived from the figure; the character ♑ is by no means ſo authentic, nor, except in England, ſo general.

(XI.) AQUARIUS, ♒ expreſſes well enough ſtreams of water, whether floods or rains.

(XII.) PISCES, (♓) is evidently derived from two fiſh, tied back to back.

The characters ♈ and ♎, occur on the Egyptian obeliſks now at Rome: ſome characters for ♉ ſeem to hint at the head and fore legs of the bull, as commonly drawn on the celeſtial globe.

CHARACTERS OF THE PLANETS.

(I.) The character of the SUN ☉ (a circle) ſeems to be merely a delineation of this glorious centre of the ſyſtem; and needs no engraving to render it intelligible. The character ⊙ (a circle with a knob in the middle) imitating a buckler, has been attributed to the ſun; ſo has alſo a cone. But a circle ſeems greatly preferable.

(II.) ☽ the character for the MOON, is nearly deſcriptive of her appearance when partly enlightened, therefore needs no explanation.

(III.) MERCURY is ſignified by the caduceus (☿), an attribute conſtantly attendant on the heathen deity of this name.

(IV.) VENUS is expreſſed by (♀) a mirror with a handle; aptly hinting the perſonal attention of the goddeſs of beauty. The ancient mirrors were poliſhed braſs.

(V.) MARS (♂) a ſpear and ſhield, as god of war.

(VI.) JUPITER (♃) the firſt letter of his Greek name (Zeus) with a ſtroke of abbreviation.

(VII.) SATURN (♄) a ſickle; originally a ſcythe, which refers to his Greek name *Cronos* (Time), whoſe effect is, to cut down all things without remorſe.

(VIII.) The earth is marked by a circle with a line croſs it.

(IX.) The character adopted at preſent for the Georgium Sidus (Mr. HERSCHEL's diſcovery) is an H with a globe pendent from the middle of the croſs ſtroke.

PLATE XI.

COMETS.

Fig. 1. repreſents the famous comet of 1680, which, partly becauſe of its own remarkableneſs, and partly becauſe it had the fortune to be obſerved by the ableſt aſtronomers and mathematicians, is among the moſt notorious of theſe phenomena; and may be conſidered as having laid the foundation for a juſt theory of their principles and motions.

It advanced ſo near to the ſun, that at its perihelion it was not above a ſixth part of the diameter of that luminary from the ſurface thereof. NEWTON thought it ſuſtained a heat two thouſand times greater than that of red-hot iron. HALLEY ſays, this comet, in paſſing its ſouthern node, came within the length of the ſun's ſemidiameter of the orbit of our earth; had the earth been then in that part of her orbit, the attraction would have changed as well the plane of the terreſtrial orbit, as the length of the year. Who can compute the power of the ſhock, had it been commiſſioned to ſtrike us! The further limit of its orbit is calculated to reach fourteen times the diſtance of Saturn.

This plan ſhews the path of the comet while viſible to the inhabitants of earth; advancing in Nov. 1680, returning, (and from the ſituation of the earth ſeen much ſooner) from December to March 1681. The apparent length of its tail increaſes according to the ſtation from whence it is ſeen. It is many millions of miles in real extent.

Fig.

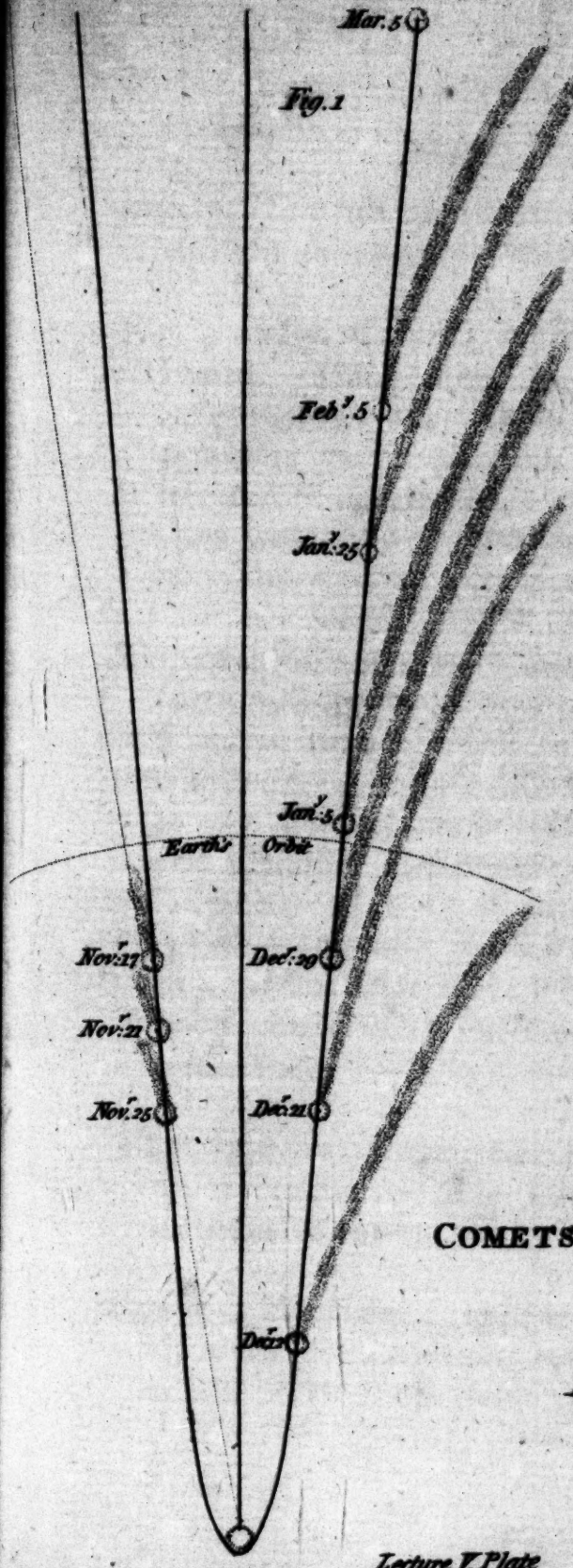


Fig. 1

Fig. 2

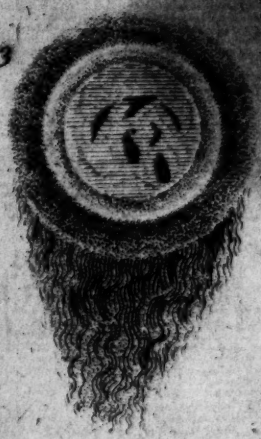


Fig. 3

Fig. 4.

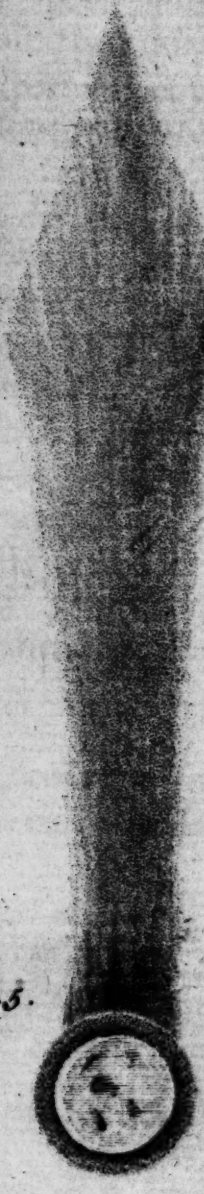


Fig. 5.

COMETS

Lecture V. Plate

Fig. 2. Comet ſeen 1744. From a drawing made at Cambridge.

Fig. 3, The tail of a comet ſo ſituated, and ſeen *fore-ſhortened*, turning downwards, that it ſomewhat reſembles a beard.

Fig. 4 and 5. Comets, whoſe tails may be likened to a flaming ſword. Many other forms ſuggeſt themſelves to a fertile imagination; that theſe vapours may vary in their properties is very ſuppoſable; but the general panic they have heretofore occaſioned, together with the ſtation from whence they were viewed, has been the moſt fruitful ſource of tremendous and terrific appellations.

The tails of comets are ſuppoſed to be atmoſpherical vapours ſurrounding theſe bodies, which are no ſooner arrived ſufficiently near the ſun to feel his influence, than they become exceedingly rarified; and are extended proportionally to the heat of their ſituation. They are extremely fine and pellucid, and permit the ſtars to be ſeen through them. The cauſe of their aſcent *oppoſite* to the ſun, is a difficulty, which ſeems beſt anſwered by ſaying, they follow the impulſe of the ſolar rays; which, ſtreaming *from* the ſun, carry with them theſe extremely volatile particles through the free æther.

The vapours of the cometary tails have been calculated by obſervation, to be ſo long as forty, ſixty, or even eighty millions of miles.

Comets, like planets, appear from the earth to be direct, ſlower than their real motion, retrograde, and ſtationary, during ſo much of their courſe as can be ſeen.

LECTURE

LECTURE VI.

IN a former lecture, LADIES and GENTLEMEN, we obſerved the very great diſtance of thoſe heavenly bodies which yet we called our neighbours, and who, with ourſelves, compoſe one ſyſtem; Saturn is diſtant, the Georgium Sidus diſtant, the remoter extremes of the cometary orbits very diſtant;—but what are theſe intervals to thoſe of the ſtars whoſe ſplendour we behold! whoſe neareſt eſtimation is four hundred thouſand times the diſtance of the ſun from us; this, I ſay, is the eſtimated diſtance of the neareſt; there are others, very, very much beyond; how noble then the powers of the mind! which not only ſpeculates on theſe regions, but after vaſt additions of ſuppoſable ſpace, repeated, and multiplied, feels its infinite remoteneſs from the heaven of heavens!

The mind ſurveys a ſtar in the zenith, or in the horizon; imagines itſelf preſent among a ſyſtem on the right hand, then (how ſwift is thought!) reverts to another on the left; thus it inveſtigates ſpace: by the ſtars too, it inveſtigates time; it conceives a period ere they exiſted, ere one lambent flame illuminated the vaſt expanſe; it conceives their revolutions, their orbits, their periods, and, more than that, it awaits

their

their extinction, and diſſolution. Darkneſs may again enve-lope the ſpheres, and every cheering ray withdraw; yet the human ſoul expects to ſurvive; and however it may witneſs the expiration of all things, to itſelf it arrogates immortality: and juſtly, for the heavens ſhall decay, and be replaced by ſucceſſors; like ſome magnificent prince, who changes to-day the garments of yeſterday; ſo the "Eternal as a veſture ſhall fold them up, and they ſhall be changed." This ſight we expect to ſee;—the very idea confutes the ſuggeſtions of thoſe who think we are merely enlivened hovels of clay: no, the inhabitant and the building are different; a breeze may over-throw this, the ſettling of a moth upon it may overweigh it; but the other ſcorns the duration of time, and extends its exiſtence parallel to eternity.

The diſtances I have mentioned, LADIES and GENTLEMEN, though not beyond mental comprehenſion, are yet exceedingly difficult to reduce to regular, or proportionate meaſurement; the rapidity of a cannon ball is loſt in the computation; the velocity of ſound, which is double that of a cannon ball, would require four million eight hundred thouſand years to reach us; and light itſelf, which arrives from the ſun in about eight minutes, is, during ſix years, travelling from one of theſe ſtars to us. So that ſhould it pleaſe God to an-nihilate one of theſe luminaries, we ſhould ſtill continue, during ſix years, to receive thoſe beams it had previouſly emitted. After this obſervation, it ſeems almoſt needleſs to mention, that they at leaſt equal the ſun in magnitude,

ſince

ſince it is open to remark, that otherwiſe their powers would be too weak to render them viſible here. It has indeed been thought, that our ſun is a ſtar of rather moderate dimenſions; and by no means ſo brilliant to ſome of the celeſtial bodies, as they appear to us. Leaving this matter thus hinted, we may proceed to obſerve, that certainly theſe ſtars are endowed with native light, *i. e.* they are SUNS, and very probably have around them many revolving planets, whoſe light being only reflected, is by far too feeble to reach this reſidence of mortals.

It requires but little attention to diſcover, that the heaven is replete with ſtars; and if theſe ſtars are at different diſtances, it is very ſuppoſable that ſome ſhould be behind others; indeed it *may* happen that the nearer ſhould entirely conceal the remote; but it actually happens, in many inſtances, that the nearer and the remote appear ſo combined, as to ſeem but one to the naked eye, and are ſeparable only by the beſt glaſſes: further ſtill, it ſometimes happens, that a cluſter of ſtars appear as one only, and form a ſpeck of light by their united powers: nor is the ſtrongeſt inſtrument happy enough to ſhew any diſtinct ſeparation between them. Of this we may eaſily conceive, if we advert to that part of the heavens called the milky way; which is no other than a prodigious aggregation of ſtars, at ſuch ſmall diſtances, as rather to produce one united efflux of light, than any diſtinct ſplendour: yet, among this luminous path of ſtars, a teleſcope diſcovers many and conſiderable intervals, as well as NEBULÆ, or UNIONS.

There

There are alſo PERIODICAL ſtars; which ſometimes are extremely bright, ſometimes ſcarcely viſible: but which conſtantly preſerve the ſame places in the heavens. Some perſons account for them, by ſuppoſing there may be half ſuns among the ſtars, or that only one part of their ſurfaces is fitted to emit light, the other being cruſted over with ſpots, which, by periodical rotations, are turned toward and from us, alternately. One hazards nothing in theſe regions of conjecture; perhaps ſome ſuns may move to their planets, and, at their neareſt approaches to us, be much brighter than at their furtheſt diſtances.

But there are alſo ſeveral ſtars, which, for aught we ever can diſcover to the contrary, are entirely NEW: I confeſs, it ſeems to me not unlikely, and we are certain it is not impoſſible, that Deity ſhould be always employed in creation. On our own terrene habitation, millions of creatures are perpetually ceaſing, and other millions of new-made deſcendants appointed to ſupply their places; all is mortal and periſhing; but all is revived and reſtored; ſo that death, triumphant death himſelf, is incapable of deſtroying the never-ceaſing renovation. What, therefore, forbids our ſuppoſing, that among the regions of ſpace, divine power may ever employ its energy, in forming new worlds, and new ſyſtems of worlds?

Whether it be fact, that any ſtars abſolutely new ever came to our knowledge; there is no doubt but ſeveral, which have been for a time extinguiſhed (or whoſe light at leaſt has been too feeble to reach us), have actually been RENOVATED: whether, by burſting the ſpots which covered them, or by the

falling of ſome comet into them, which augmented their powers with freſh fuel, is beyond our determination.

The ſtars themſelves are wonderful luminaries; but what ſhall we ſay to thoſe SPACES in the firmament, which are RESPLENDENT, yet without ſtars; and throughout which ſeem vaſt expanſes of light! If any inhabitants be there, they enjoy perpetual day, and never know obſcurity or darkneſs. Are we permitted to view theſe ſpaces, as exemplars of that perfect glory we are taught to expect? Are they reſidences of bliſsful ſpirits?——Are they——but by what principles ſhall human knowledge anſwer? We confeſs our ignorance, and adore in ſilence.

If there was no utility connected with the ſtars as ſeen from the earth, their magnificence and vivacity would ever excite admiration; but beſide the advantages they afford us on ſundry occaſions, whereby we aſcertain many uſeful facts, there is in particular one, the POLE STAR, to which we are beholden for almoſt all the facility of our navigation. This ſtar, by being ſituated in that part of the heavens to which the north pole of the earth points, performs the office of a director and guide, to thoſe who, on the mighty waters, were elſe unable to determine their proper courſe. But it is evident, that if a veſſel keeps any certain and fixed point, to the right hand, or to the left, it muſt very greatly contribute to aſcertain the courſe it purſues, whether going or returning; ſuch a point is the pole ſtar; ever remarkable, and not leſs ſo ſince the happy diſcovery of the magnetic virtue, which points the compaſs to the Pole.

What

What obligations are we not under to that noble and powerful invention, the teleſcope! by whoſe aſſiſtance we become acquainted with the preceding facts: how many thouſand objects has it diſcovered, which to human eyes were formerly inviſible! In the conſtellation Pleiades, commonly termed the Seven Stars, have been ſeen at leaſt ſeventy ſtars. This may hint a caution to us, when reaſoning on ſubjects beyond our powers: there exiſt many principles, and cauſes, not to be diſcovered without what I may term, *teleſcopic* aſſiſtance.

This magnificent firmament, decorated with ſtellar fires, has ever been among the favourite ſtudies of mankind: it is true, the day is the time for activity, and diligence; man is therefore engaged to purſue his buſineſs by a flood of light poured forth around him, and few inducements divert his attention from his immediate concerns; but that none of his time may be waſte, even in the periodical abſence of the moon, the ſtars attract his contemplation, and direct upwards his attention, his views, and his deſires.

The whole of what we ſee is probably but a part of the great, the univerſal ſyſtem:—whether we are in its extremes, or whether nearer its centre; whether its centre be the beatific preſence, around which circulates the whole; or whether our appointed heaven be nearer our abode, we know not: but we know, that Deity is every where; equally viſible by the operations of his power, on our own globe, in our own country, in our own perſons, as if this was the only diſtrict of his dominion, and his peculiar reſidence was among the ſons of men.

LADIES and GENTLEMEN,

WE have now completed what we propoſed, in our Survey of the Celeſtial Phenomena;—when ſubjects of importance, and magnitude, engage our attention, it is neceſſary, not only to inſpect them part by part, but alſo to conſider the general reſult, the *effect* of the whole: thus ſome magnificent edifice, not only delights and pleaſes by its ornaments and decoration, but by the ſymmetry and proportion of its parts, by united elegance and greatneſs, commands admiration and applauſe. Such is the effect of the heavenly phenomena; each in his orb is intereſting; each in his orb proclaims the power and wiſdom which appointed it; each in his orb exemplifies Almighty ſkill, and obeys Almighty direction, ſolicitous to be found in his ſtation, and freely performing his courſe, in profound ſubmiſſion to its author's original *fiat*, and continued impulſe.

The reſult of the whole, is the moſt auguſt chorus of praiſe of which mortals, like ourſelves, can form any conception; and, indeed, in order to form a conception (imperfect as it is) of this combination, we are obliged to uſe every art, and to ſummon all our powers. We begin with an inſtance moſt obvious, and proximate; we riſe from this to a ſecond, from a ſecond to a third, till we viſit tracks of light. Such is the progreſs we have purſued in this ſeries of Lectures; our appointed luminary aſſiſted us to imagine the properties of luminaries almoſt infinitely remote; our native ſyſtem ſupported our gueſſes at ſyſtems beyond our inſpection;

inſpection; and our planetary chorus aided our ideas of that general, that univerſal chorus, that ſyſtem of ſyſtems, whoſe combination affords perpetual meditation and reflection. Yet, after all which can be ſaid on the contrivance of worlds, after all our remarks on the wiſdom evident in their formation, and the ſkill manifeſt in their conſtruction, one adoring thought in the human mind, one effort of riſing gratitude, one ejaculation of genuine praiſe, is infinitely ſuperior in value to all their ſplendour: actuated by no principle of love, but impelled by power, excited by no deſire of acceptance, but obedient merely as revolved, they eſteem not, nor adore, nor praiſe, (but paſſively) their omnipotent Author; let then thoſe who can actively eſteem, admire, and adore, let thoſe ſupply their deficiency. Theſe heavenly objects call, and with no feeble voice, on every power of our minds, and excite to ſuch duty every principle of reaſon, reflection, and thought.

Reflective adoration is not only the moſt proper and direct, but alſo the moſt facile and eaſy employment of our faculties; it requires not depth of ſtudy, unweariable continuance of obſervation, life-long engagement of attention and remark; yet is unqueſtionably certain of divine ſucceſs and acceptance.

If, on many occaſions during the courſe of theſe Lectures, we have had occaſion to acknowledge our ignorance, to own that the works of Deity are beyond our conception, with what humility ſhould we think and ſpeak of DEITY itſelf! The whiſper of his ability we hear, but the thunder of his power who can tell? A ray of his ſplendour we diſcern,

but what is the weight of his glory? A ſpan repletes our limited faculties; if we extend our ideas beyond ſubjects with which we are intimate, we quickly feel a memento which adviſes us, that moderation is wiſdom. Though we conceive a period antecedent to the ſtellar fires, though we await the cloſe of their exiſtence, and thus conceive of duration; though we add to regions of conſtellations other regions beyond them, roving in idea through realms of ſplendour, and thus conceive of ſpace; by all this, what advance have we made in conception of HIM, to whom all time is NOW, and all ſpace A POINT!

Upon much the ſame principles as the Zodiac was originally diſtinguiſhed, have the other parts of the heavens been *peopled* with men, animals, and objects, according as the imagination of beholders *made* or found a likeneſs. Moſt of theſe figures (termed CONSTELLATIONS) are of high antiquity, and many of them refer to the Argonautic expedition (before A. D. 955 years). Others are added ſince, in alluſion to poſterior incidents; and, but in the laſt century, one particular ſtar was named *(cor Caroli)* Charles's heart, in memory of Charles I. of England. What ſtars are not included in any conſtellation are termed *unformed*; but the conſtellations are now drawn ſo as to omit as few as poſſible. Theſe contrivances are of great uſe to aſtronomers, but to them only; and are ſeldom well underſtood without the aſſiſtance of a Globe.

The conſtellations and their forms differ in various nations.

LECTURE VII.

THE eagle, in elevated ether, riſing beyond the track of mortal eye, and ſoaring in regions of aerial ſpace—yet feels, that far below is his aerie, his habitation, his abode, the objects of his care, his tenderneſs, his anxiety, to whom he returns with rapid wing, with energetic velocity: ſo we, who have mounted, in former diſcourſes, "beyond this viſible diurnal ſphere," who have traverſed realms of light, and expanſes of ſplendor, who have examined refulgent orbs, diſtant, —immenſely diſtant! yet, with invigorated delight and complacency, we turn our attention to that globe of which we are natives: in contemplating other ſpheres ſurpriſed and pleaſed, not intereſted; our admiration is the not to be withheld applauſe of a caſual ſpectator, but void of the heart-felt rapture of permanent enjoyment: whereas, when we ſurvey the earth, our dwelling—when we inquire its properties, explore its conſtruction, or inveſtigate its productions, it awakens the finer feelings of the mind, it claims an intimate relation, a perſonal concern, a ſentiment, which ſtrongly connects with the tendereſt paſſions of humanity.

The Earth, LADIES and GENTLEMEN, is a planet among the planets; and performs its revolution around the central ſun; whoſe invigorating beams viſit every part of it, but not

at all times in equal proportion: the cauſe of this inequality, as producing the SEASONS, ſhall be, if you pleaſe, our firſt inquiry.

If the earth was upright (*i. e.* perpendicular to the plane of its orbit), the ſun would of courſe be perpendicular to the middle (or equator) of the earth, and exactly equal in diſtance from each extreme (or pole) of the globe; each extreme would enjoy as long continued ſight of the ſun as the midſt; and the ſame light, heat, and ſeaſons, would be univerſal and permanent. The earth would indeed revolve on its axis, producing equal night and day; but no other revolution would be ſenſible to creatures upon it. Was this the original conſtitution of our globe? I ſometimes think it was; fancy catches the idea, ſuggeſts the vivid landſcape, paints perpetual ſpring, ever-blooming flowers, ever-delicious fruits, at once in bloſſom and mature on the ſame fertile tree, offering to the raviſhed ſight tints of exquiſite beauty; to the delighted taſte juices of nectareous flavour; fancy views around brilliant verdure, groves of majeſtic trees, alleys of fragrant ſhrubs, myrtle bowers, and violet banks; unites the crocus and the lily, the ſnow-drop and the roſe; hears the murmuring caſcade, the tinkling rill, or ſtands enraptured at the broad limpid ſtream, which, ruſhing from the hill ſide, purſues its courſe in circling eddies, or in tranſparent miſt diſperſes gentle dew o'er every herb;—theſe are the delights of fancy; but ('tis like awaking from a pleaſant dream) fact denies their exiſtence; or if it ſuffers a glimpſe at ſome of them, it forbids their union and their perpetuity.

By

By the ſimple principle of changing the ſituation of the earth from perpendicular to inclined, and eſpecially, when that inclination is ſo great as twenty-three degrees and a half, the face of nature is changed alſo; and now the earth, at one part of its ſurface, ſuffers extreme heat, at the other, intenſe cold; here the luminous eye of heaven quits not the conſtantly enlightened region, while there he refuſes to ſhed one ſingle ray, to cheer the torpid ſtagnation of frozen nature.

If the earth had no annual revolution, but abode conſtantly in the ſame place, it is clear there could be no change of ſeaſons: but if in the northern hemiſphere it was ſummer, it muſt ſo continue; as the ſouthern hemiſphere would be involved in winter: the cauſes for which may be reduced principally to theſe: (1.) This ſituation of the earth would expoſe the northern part of it conſtantly to much *longer* action of the ſolar rays; it needs no enlargement to prove, that proportionately ardent heat would be excited by this circumſtance, or that heat would promote vegetation, and ſo on; (2.) Such a ſituation of the earth would expoſe the northern part of it conſtantly to the more *direct* action of the ſolar rays, whereby the heat would be exceedingly augmented, as well, becauſe a greater number of rays would fall on any given ſpace, as becauſe, when they had fallen, they would be reflected to a much leſs diſtance, and in a much ſharper angle. As when you have thrown a ball againſt a wall, if you threw it nearly ſtrait, it rebounded nearly ſtrait to you; but if you threw it obliquely, off it went to a yet farther diſtance; it did but juſt glance, and was gone. This you have often obſerved.

Theſe circumſtances muſt be reverſed in the ſouthern hemiſphere, ſuppoſed as before; I ſay, it would be deprived of the ſolar rays, or enjoy them for a very little time; during which time they would fall very obliquely, and conſequently be reflected through the atmoſphere, ſo as to fly off without farther effect.

If we ſuppoſe a dozen of preciſely ſuch earths ſo ſituated, extended in a line laterally by each other, they would be all alike, and all fixed as to their ſeaſons: but if we ſuppoſe them placed in a circle round the ſun, the caſe is inſtantly altered; if to one it was ſummer in the north, to its oppoſite it would be ſummer in the ſouth; if to one it was ſpring in the north, to its oppoſite it would be autumn in that hemiſphere: this contrariety would be regular throughout all the oppoſites. We have only to place a ſingle globe ſucceſſively in the places of theſe twelve ſuppoſed globes, and the idea is rendered perſpicuous, and facile; we ſee at once, that what was formerly moſt directly turned to the ſun, is now turned from him; and what was formerly denied his beams, now enjoys them in profuſe abundance: ſuch effects ariſe from the inclination of the earth to the plane of its orbit.

The axis of the earth (or its inclination) is fixed, is conſtantly the ſame, points to the ſame place in the heavens; but its ſurface is ever in motion, and from hence ariſe other changes, which have no relation to the ſeaſons. The ſurface of the earth is ever in motion, rolling ſteadily from weſt to eaſt, with unperceived gradation; yet not the leſs real becauſe unperceived. By this rotation of the earth, thoſe bodies which are too diſtant to move with it ſeem to move contrarywiſe, from eaſt

to weſt. Do you aſk why we do not feel this motion? I reply, we are too diminutive: I aſk, in return, what proportion a man of ſix feet bears to (four thouſand miles) the ſemidiameter of the earth? and I refer you to conſiderations and proofs that it *muſt* be ſo, whatever be our feelings on the occaſion Is it credible that we diſcern the operations of nature, ſo as to truſt to the judgment of our feelings, or our ſenſes? And what good reaſon can be given, that the diurnal motion we obſerve in the heavenly bodies ſhould not as well (much rather) originate in our own globe than in the heavens, notwithſtanding appearances?—But for proofs of the fact, take the following hints; *firſt*, I wiſh to aſſert, that our ſenſes are not competent judges of any occurrences not neceſſary to human life, to which they are more immediately adapted, and for which they are conſtructed and appointed; *ſecondly*, That in many reſpects they deceive us in ſubjects nearly related to human life itſelf; if they be preſented to us diverſe from what we are accuſtomed to. Our faculty of judgment connects ſo many things together to form a determination, that it eaſily errs if any of thoſe things be varied. How badly ſome perſons judge of diſtance! A countryman thinks a ſtreet in town a very different length from what it is: as a townſman thinks a mile in the country a dreary ſpace indeed! and ſo tireſome! though he walks half a dozen in a day among the buſtle of London without fatigue. How exceedingly have all of us occaſionally varied in our judgment of the progreſs of time! When pain has afflicted us, how ſlowly he moves! every moment is an hour! But when the ſprightly dance exhilarates our ſpirits, the morn-

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ing may ſurpriſe us ere we think it night. We judge of all things by compariſon: like thoſe who, deſcending from the frozen ſummit of a mountain, bathe themſelves in a ſtream at midway, that they may enjoy the grateful warmth; from which grateful warmth, as exceſſive cold, ſhrink back thoſe aſcending from ardent plains below. The progreſſive motion of a ſhip under eaſy ſail is not felt by thoſe on board; no, the land recedes and diſappears: to a man ſitting in a windmill, while it moves round the poſt in the middle, the poſt ſeems to move. But why ſhould I refer to theſe things, though well known, and undeniable, when we have ſo lately proved the fallacy of appearances in the motions of the planets: they are really always direct, yet ſometimes they appear retrograde; they are conſtant in motion, yet ſometimes ſeem to ſtand ſtill. Let us then acknowledge, that it *may* be that the ſun does not daily go round the earth, but that the earth goes actually round its own axis, and thereby turns ſucceſſively every part of its ſurface to the ſun: this granted, we muſt never forget, that the apparent motion is always contrary to the real; that in the morning the part whereon we ſtand moves toward the eaſt, *i. e.* (we looking ſouth) from our right to our left: we may call this toward the ſun (*i. e.* toward the ſeat of the ſun, as termed in perſpective), we advance more eaſterly till noon, when we are directly oppoſed to the ſun, and nearer him by half the diameter of the earth; from noon, we decline from him, ſtill moving eaſterly, and he ſeems to decline to the weſt: at length, the rotundity of that part of the earth which has ſucceeded to our former poſition, totally conceals him from

our

our view, till the rotation of the globe again preſents him in an oppoſite part from that wherein we laſt ſaw him.

If the earth had no diurnal rotation, it would be unlike its neighbour planets, for they have: the heavenly bodies, diſtant, large, and ponderous as they are, muſt move around the earth with a rapidity beyond all meaſurement: inſufferable rapidity! enough, I verily think, to throw them into diſorder, and to deſtroy the balance of attraction among them. And for what benefit?—*none to us*: ſhall all thoſe luminous, thoſe magnificent orbs merely roll round us? ſo many large objects attend on one ſmall! The thought is unworthy a wiſe man; ſuperior intelligences would bluſh at the ſuggeſtion.

From the concurrence of theſe two principles, (1) that the earth circulates round the ſun, and (2) that it revolves on its own axis, ſeveral circumſtances ariſe, which I proceed now to mention. It is evident, that to ſome part or other of the globe, the ſun muſt be vertical conſtantly (making noon); but as the earth expoſes progreſſively its polar parts to the ſun, the verticality of the ſun changes place. Imagine him firſt to be vertical at the equator (exactly at the LINE, or mid earth), from whence he proceeds northward, if you pleaſe, daily changing his vertical ſtation till he arrives at twenty-three degrees and a half, north latitude; here he ſtops: for no ſooner has he arrived at this ſtation, than the ſame cauſe which gave him this apparent height of latitude (the courſe of the earth around him), promotes his return to his former ſtation, the equator; which paſſing, he now inclines as much to the ſouth, as before he did to the north,

i. e. twenty-three degrees and a half. This apparent course of the sun is wholly owing to the inclination of the earth: if the earth was inclined thirty or forty degrees, so many degrees would the sun appear to advance and to recede. I think it very natural to distinguish that part of the earth, which lies thus exposed to the direct rays of the sun: it is well termed the TORRID ZONE; expressive of its constant heat. The extremes of this course of the sun are called TROPICS; the northern, the Tropic of *Cancer*; the southern, the Tropic of *Capricorn*; because the sun is in those signs when in their respective tropics.

It remains to be observed, that, at each tropic, the course of the sun seems for a few days not to vary; but although he actually advances or recedes, yet it is not perceptible without accurate observation: this, together with his never exceeding these limits, has given occasion to term them sun-stations, (*Solis statio*) or SOLSTICES: the summer solstice being when this great luminary seems to us highest in the heavens; the winter solstice, when he is lowest: the medium is termed equal night and day (*Equinox*, equal night); which then obtains throughout the globe. This is clear enough; at the summer solstice we have long days and short nights; at the equinox, day and night are each twelve hours; at the winter solstice, long nights and short days.

By the tropics, we have distinguished a band on the middle surface of the earth, of twice twenty-three degrees and a half in breadth; where the sun is directly over the heads of the inhabitants, where he sheds his rays most immediately, most vigorously

gorouſly, and moſt plentifully, producing extreme heat.—Such is the centrical ſurface of the earth—the Torrid Zone.——Let me now contraſt this with the extremes of the earth, its poles, which being fartheſt removed from the tropics, are fartheſt removed from theſe effects: for here, the ſun is not only never vertical, but ſometimes never viſible; that is to ſay, when the ſun is in the ſouthern tropic, he is too far ſouth for his beams to reach the north pole; for ſo long time, therefore, as he is highly ſouth, the north is deprived of his influences; as he returns to the equator, he advances to the north; at the equator, he produces the equinox; as he advances to the northern ſolſtice, he produces ſummer; and now the ſouthern pole is deprived of him, and he is conſtantly viſible to the northern. We have thus deſcribed two parts of the globe, where alternately reign perpetual winter, and perpetual ſummer; each of theſe, if you pleaſe, ſhall contain twenty-three degrees and a half; and the line which bounds them being drawn round the pole, is of courſe circular; call therefore the northern boundary, the northern or ARCTIC CIRCLE, and the ſouthern boundary, call the *anti-arctic* (ANTARCTIC) CIRCLE. What portions of the globe remain unnoticed, muſt evidently lie between the tropics and theſe circles; which not being ſubject to the fervour of vertical ſuns, nor to the rigour of polar winters, may juſtly be named TEMPERATE: the temperate belts (or zones) are the happy mediums, between the extremes of the torrid zone and the frigid zones.

Methinks I obſerve in the countenances of ſome of my auditory, a kind concern for the inhabitants of theſe *oppoſitions*

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of the globe: how do the tropical inhabitants endure ſuch intenſe heat? and how can the polar natives live through an arctic winter? The concern is extremely *à propos*; and thus I wiſh to moderate and anſwer it. Providence well knows the wants of its creatures; I ſhould rather perhaps ſay, of its creature (MAN), ſince man alone is capable of inhabiting this globe in its various extremes; other creatures either can ſuffer cold, but are deſtroyed by heat; or enjoy heat, but cold is death to them: man only can endure heat and be ſtill himſelf, or can abide uninjured among perpetual froſts and endleſs ſnows.

The wants of mankind, as ariſing from the cauſes we have mentioned, are, either a deficiency, or a redundance, of (1) light, or of (2) heat.

Permit me to ſtate it thus: the polar regions, by being long deprived of the ſun, ſeem to be alſo deprived of their ſhare of light; this is, however, only ſeeming; for (1) although they are thus dark in winter, yet in ſummer they have perpetual day for ſo long as balances and correſponds to their winter darkneſs; and in the equinox, they enjoy the general diſtribution; they have then, on the whole, an equal ſhare of ſun light: (2) the moon, by her variation from the path of the ecliptic, is their frequent viſitor, and yields them light enough for moſt purpoſes of life (which by the bye, if ſhe were confined to the ecliptic, ſhe would not do); they have therefore their ſhare of moon-light. Add to this (3), by the refractive power of the atmoſphere (to be conſidered hereafter), they have a very greatly lengthened, if not a perpetual, aurora, or twilight:

not

not to inſiſt on the ſervices of (4) the aurora borealis, of whoſe brightneſs in thoſe countries, we have no conception in this. Admit now, that, take the year through, they have at leaſt as much light as ourſelves; only they differ, in having it more together and at once. As to heat, it may be ſaid to follow, from what is juſt aſſerted, that they have plenty; in fact, if vegetation may decide the matter, its progreſs is in their favour; they commit their ſeed to the earth, it ſprings up, increaſes, ripens, and is cut down, in a few weeks: where lately was hardened ſnow, now grows waving corn; where lately were rocks of ice, now ſhoot variegated flowers; and up riſe, almoſt as a traveller treads, groups of verdure, and cluſters of herbage. I ſhall not enlarge on the animals caught in winter, whoſe furs and whoſe fleſh are valuable to the polar inhabitants; yet it might bear admiſſion among other conſiderations, which induced the Siberians to aſſure Czar PETER, that *their* country was the ſeat of PARADISE!

Turn we now to the tropics, and ſee how Providence has manifeſted its care for them. Mankind will theorize; it ſeems an innate diſpoſition; the uſe of knowledge is to correct, or to eſtabliſh theory; herein we glory. The ancients thought the arctic regions too cold for habitation, the torrid zone too hot; our better information corrects this error, and proves the general care of the general Author. The heats of the torrid zone are moderated by ſeveral cauſes. For though the ſun be vertical, yet he is never more than twelve hours above the horizon; conſequently, the night is nearly twelve hours long. Here then is time for enjoyment; here

is a daily balance inſtead of an annual, which, at once, almoſt ſettles the affair. Add to this, that evening breezes cool the air; that in ſome places conſtant tranſparent vapours veil the ſun, or rains deſcend to refreſh the earth, or the heat being chiefly on the ſurface of the earth, every elevated ſtation (and where are mountains equal to thoſe at the equator?) is exalted into cooler air; and we may well conceive even the tropics to be populous.

There is yet another balance, before we cloſe our account of the effects ariſing from the courſe of the ſun: in our northern hemiſphere we enjoy eight days, at leaſt, more ſummer than the ſouthern hemiſphere. Partial! at once, cries a ſuperficial obſerver: perhaps not, for reflect, if you pleaſe, LADIES and GENTLEMEN, that the *aphelion* of our planet is during our (northern) ſummer; its *perihelion*, when its motion is ſwifteſt, is during the ſouthern ſummer; to this circumſtance I conceive we may impute no little force, for the ſouthern parts receiving much more heat in equal time than the northern, being moſt expoſed to the ſun's rays while the globe is neareſt to him, it had been partial, had not longer time compenſated in the North, for fiercer heat in the South.

Notwithſtanding the equality, which, when we take all things together, appears even between thoſe parts of the globe the moſt unlike, I cannot help congratulating myſelf, and the preſent aſſembly, that Providence has placed us in a latitude free from their inconveniencies. Compared with us they ſeem deprived of that happy mediocrity wherein we rejoice: we have heat enough to render deſirable the umbrageous grove,

we

we have cold enough to pulverize the rigid glebe, to prevent the increaſe of noxious and troubleſome inſects, of dangerous and venomous reptiles; equally diſtant from the frozen limbs of the North, from the boiling blood of the tropics, we enjoy that happy temperature, which not only affords ſuſtenance for the body, but leaves a leiſure for improving the mind; which exempts us from many turbulent paſſions, whoſe fury tranſports the hearts of ſome, from that ſuperſtition and ignorance, that rapacity, that tyranny, that ſuſpicion, which, however they may have ariſen or have reigned in the minds of individuals, are ſo general, as perhaps to be juſtly eſteemed vices of the climate; or at leaſt very intimately attendant on the general temperaments which originate therein.

In our happy climate the ſeaſons are diſtinctly, not ſeverely marked, as ſeverity appears elſewhere; our days glide over us, little different from morn to night, as differences occur to others: throughout the day, throughout the year, life may be enjoyed; and whoever finds cauſe of complaint, had need be well aſſured the cauſe exiſts not in himſelf; or at leaſt, let him acknowledge, that hitherto he has not extended his ideas, or compared his ſituation with that of others. Our plains are not covered month after month with rocks of ſnow, our meadows are not burnt month after month into ſcorching deſarts: I confeſs we are pretty much over-clouded; but theſe clouds contribute almoſt perpetual verdure; I confeſs the viciſſitude of our weather effects correſpondent changes in our perſons, perhaps alſo in our feelings; but we are not deſtitute of reaſon to correct this evil, nor of liberal ſtudies, nor of ſub-

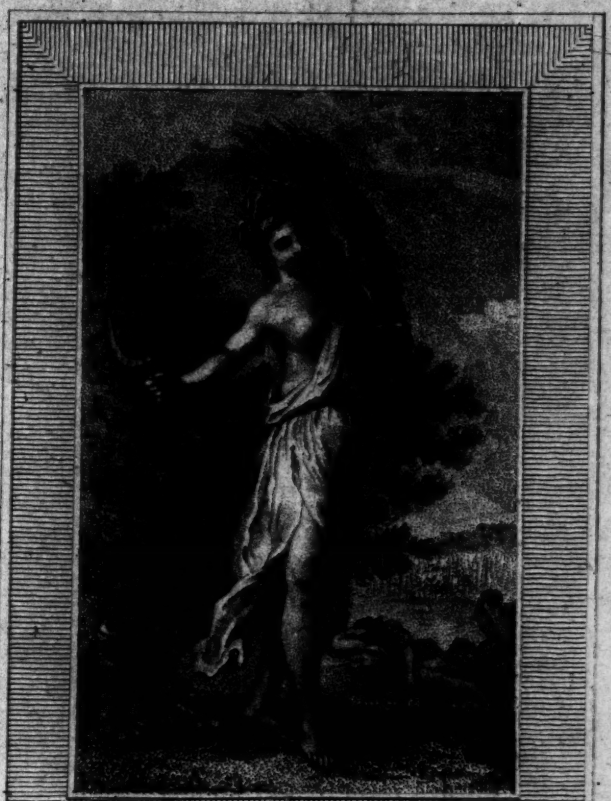
limeſt knowledge. We have not conſtant ſpring like QUITO, but we have no earthquakes; we have not the luxuriance beneath the line, neither have we the torrents, the hurricanes, the whirlwinds; far then be diſcontent away from us, far be a repining ſpirit: no, while we recount the pleaſures of the ſeaſons, let us find ſomething in each which ſhall inſpire us with gratitude, which ſhall exalt our acknowledgments to that ſovereign Author, who might have rendered our ſituation irkſome, inſtead of pleaſant, and reſtleſs, inſtead of eaſy.

Whether, as contraſted with lately boiſterous winter, or whether in itſelf it be the moſt charming of ſeaſons, SPRING is ever welcome, ever deſired; we anticipate its delightful verdure, the promiſing aſpect of univerſal nature; or, is it deſired becauſe Hope is the moſt grateful ſenſation of the heart, and Spring is peculiarly the ſeaſon of Hope? Every ſhoot of the trees we hope ſhall produce a branch, every bloſſom we hope ſhall iſſue in fruit, and the ſprouting blade we hope is pregnant with waving corn. The lengthened day is pleaſant; the mild, the fragrant air, the ſoft-deſcending ſhower; every day is more intereſting than its predeceſſor. The meadows are decorated with flowers, the feathered choir warble on every buſh, life abounds and multiplies throughout every ſpecies of creatures, animal, reptile, inſect, or vegetable. All nature, animated with reviving influence, enjoys the delights, the beauties of Spring.

The ſeaſon of Hope iſſues in poſſeſſion.—SUMMER accompliſhes what Spring had begun; if it boaſts not novelty, it is attended

SPRING.

London, Publish'd by C. Taylor N.o 10 near Castle Street, Holborn, Sep.r 12th 1787.



SUMMER.

London, Published by C. Taylor N°. 10, near Castle Street, Holborn, Sept. 5th 1787.

AUTUMN.

London, Publish'd by C. Taylor N.° 20 near Castle Street Holborn Sept.r 1787

attended by maturity and profit; if it leſs charms the eye, it gratifies the taſte, and puſhes to perfection the productions of nature. The warmth of Spring becomes heat in Summer, but Summer furniſhes the ſhady grove; and if noon be ardent, delicious is the zephyr of evening! All around is calm, ſerene, placid, noble the ſetting ſun! lively his parting ray, gilding the clouds, and gleaming over the vivid landſcape red-yellow light. To this delighting ſcene add agreeable company, the ſprightly ſally of wit, the lively converſe of cultivated taſte, or the ſolid refinements of liberal reaſoning, catching from every ſurrounding circumſtance occaſion of prolonged diſcourſe.—It is the elyzium of mortals! Let eaſtern nations loll on the lazy ſopha, or forget the ſultry hours in idle nothingneſs—heat burns up all around them, enervates body and mind, and forbids activity perſonal or intellectual: But let Britons enjoy the bleſſings of their climate; which ſuffers not heat beyond moderation, nor ever reduces the paſture-abundant meadow to a burnt-up plain, or a ſandy waſte.

AUTUMN! call around the luſty reapers, include youth and age, the ruſtic maiden with the village ſwain, prolong the daily taſk, quit not the willing labour, briſk ply the ſcythe, the ſickle, and the brown jug, be all hearts replete with mirth, even thoſe to whom belong "the corners of the field," and wide open the gate to the gleaner; ſpare not the benevolent largeſs, and let Echo repeat, repeat the joys of Harveſt-home. Theſe be thy pleaſures here: we envy not the vintage of other countries, let them cruſh the purple grape, and

prepare

prepare the mantling liquor; theirs be wine, and ours be plenty. Not that our goblet yields to theirs, while we boaſt the refreſhing juice of the highly-flavoured apple, or the luſcious pear. Theſe be thy riches, Autumn; thy bounties meet our eyes in every form, infinitely diverſified, infinitely valuable.

Nature needs refreſhment; the morning of the year, cool and placid, prepares for the activity of fervid noon, and induſtrious evening. Now the ſhades of night prevail—WINTER is the ſeaſon of repoſe: reſt from thy fertility, Earth, thou haſt filled our barns; viſit other regions, Sun, thou haſt repleniſhed our granaries; now in cheerful homage, we offer our gratitude to thee, and to Him who directs thee. For never be forgotten Him whoſe Advent teaches us to cloſe the year with piety, and to begin it with thankfulneſs: Him who directs our life as he directs the year. Happy the head whoſe ſcattered locks are grey, which can look back on a well-ſpent life! Happy the man who can ſay to ſurrounding poſterity, "follow my ſteps;" to ſuch, Winter has no ſeverity, no howling winds groan through the leafleſs grove, no terrors attend the ſweeping ſtorm; the cheerful blaze enlivens the ſocial hearth, and the young buds, from his once-young branches, exclude from him the ſterility of the ſeaſon; the merry gambol and the ſprightly dance have ſtill their pleaſure, though he nor plays nor dances; ſtill he laughs at the well-told joke; and if wit is not ſo poignant as it was ſo many years ago, if the preſent youth are leſs active than when he was young, and the laſſes leſs fair, yet he owns that in ſome things are manifeſt improvements.

Such

WINTER.

London, Published by C. Taylor N.° 70 near Castle Street, Holborn, Sept.r 1, 1787.

Such is life, ſuch are the ſeaſons ; round rolls the globe, and ſwift flies Time, ever changing ! yet wiſely ordered by Almighty ſkill and every ſeeming inconvenience productive of extenſive, important, and multiplied advantages.

Paſſing further enlargement on theſe ſubjects, I proceed to ſay a few words on the SHAPE *of the Earth*. I think the rotation of the earth on its axis is clearly eſtabliſhed ; I think alſo the fitteſt ſhape for a rotatory body is evidently a round one : that the earth is round, is evinced by the following conſiderations: (1) The ſhadows of all round bodies are round alſo : reverſe this, if you pleaſe, round ſhadows imply round bodies ; —the ſhadow of the earth is round, as appears by every eclipſe of the moon ; this is the moſt conſiderable effect of the roundneſs of the earth which appears to our ſenſes, ſince the *outline* of this circle anſwers to ſome thouſand miles in length on the ſurface of the earth. (2) The roundneſs of the earth is what hides diſtant objects from us, when no other impediment is interpoſed ; as at ſea, the curvature of the water prevents our ſeeing what is behind that curvature ; but if by any means (as a tall maſt) we may be elevated above the effect of that impediment, we are enabled to ſee beyond it: this is ſo notorious to every ſailor that it needs no proof. (3) The ſame effect occurs when we ſtand on the ſhore ; the higheſt part of a ſhip is what firſt comes in view, advancing to us ; is what laſt quits our ſight, when going from us. This convexity not only attends large bodies of water, but alſo rivers if traced in their courſes, exhibit the ſame appearance. On a river, a little boat may be ſeen at a mile diſtant ; but if you ſtoop down,

lowering the eye pretty near to its ſurface, the water will ſeem to be elevated, and will conceal the boat. Nay, we are told by Baron Du Tott, that in the Crimea, (4) The earth is as level as the ſea, and that he ſaw the heads of men at a diſtance juſt peeping above the horizon, and moving on along it, while the reſt of their bodies was concealed by it. In fact, the only occaſion of appealing to water, is becauſe it is the moſt level, and not ſubject to the riſings or hollows which contribute to deception on land. (5) The globe has been circumnavigated: now had it been other than round, the boldeſt prow could only have ſailed to its extremes; where it muſt have been blocked up by impaſſable barriers, or have ſunk into ſome profound abyſs.

But when we ſay the earth is round, we affirm alſo that it is ſomewhat more in circumference at the equator, than acroſs from pole to pole: it is, I ſay *flatter* at the poles, than at the equator; and with reaſon, for at the equator, being the moſt rapid ſuperficial motion of its daily rotation, both land and waters ſeem to have felt its influence; and to be aſſembled in conſequence. This is proved by actual meaſurement; by which we find that a degree on the globe is not the ſame ſpace (but ſomewhat larger) under the arctic circle, as at the equator; by the incorrectneſs of pendulums, which under the line loſe the truth given them in England; by the immenſe mountains; by the calculated height of the ſea; and by the velocity of the marine ſurges; all agreeing to demonſtrate the elevation of our globe at the equator, and its conſequent depreſſion at the poles: though the difference be but one hundred and eightieth part, or 178 to 179.

One

One of the ſtrongeſt arguments for the rapid rotation of Jupiter (beſide actual obſervation), is his ſhape; which differs in meaſure between his poles, and at his equator, as 12 to 13.

As to the heights of mountains or depths of vallies, they are not equal to the roughneſſes on the ſurface of an orange; which yet nobody ſcruples to call round.

If the earth is round, there muſt be ſome places whoſe inhabitants are our ANTIPODES, *i. e.* whoſe feet are oppoſite to ours; for every place muſt have its Antipodes; ſince all points on the ſurface of a globe, muſt have oppoſite points: otherwiſe it implies chaſms and breaches. It follows alſo, that at antipodial (or exactly oppoſite) meridians of the globe, the parts of the day are contrary: morning to one, evening to the other; noon to one, night to the other. The ſeaſons alſo are contrary in contrary latitudes, as already explained.

Thus have we noticed the principal particulars of our earth conſidered as a planet. Is there not much pleaſure accompanying ſuch enlarged views of its general properties! In conſidering all men as brethren, however diſtinguiſhed by various climates, or ſeparated by local diſtances! O that the general viciſſitudes of light and darkneſs, of heat and cold, of ſunſhine and clouds, of fair weather and tempeſts, might promote equally general ſentiments of humanity among mankind!

OBSERVATIONS ON THE PLATES

Belonging to LECTURE VII.

PLATE I. SHAPE OF THE EARTH.

FIG. 1. and 2. Theſe figures are examples of the application of the principle adduced in the Lecture, p. 147. A fig. 1, repreſents a ſhip ſailing *from* the Tower B. It appears clearly, that the lower parts both of the tower and ſhip are firſt concealed by the rotundity of the circle; and are totally inviſible, while the maſts of the ſhip and the battlements of the tower are yet diſcernible. Agreeable to this idea, the figure C ſees only the maſt of the diſtant veſſel E coming to him, while he ſees diſtinctly the whole of D, which is nearer.

Fig 2. repreſents the ſame effect in ſhips *advancing* to land. A cannot as yet ſee any part of the mountain C, it being concealed by the circumference of the earth: while B enjoys a full view of it; the viſual ray paſſing clearly over the earth's circumference.

Fig. 3. HORIZON. This fig. ſhews that the ſenſible horizon (*i. e.* what part of the earth's ſurface actually bounds our view) is juſtly conſidered as coincident with the rational, or celeſtial horizon HO: for though to the figure A there

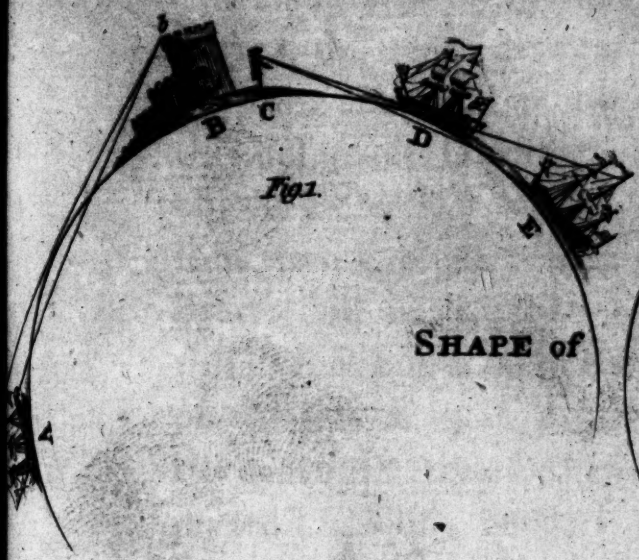


Fig. 1.

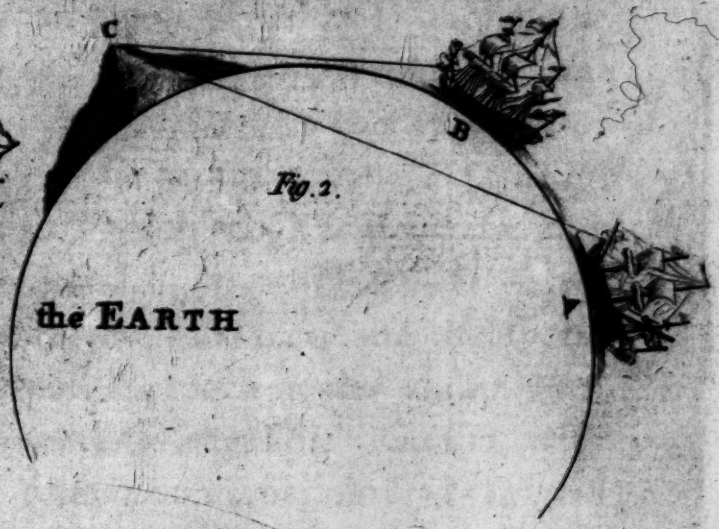


Fig. 2.

SHAPE of the EARTH

HORIZON

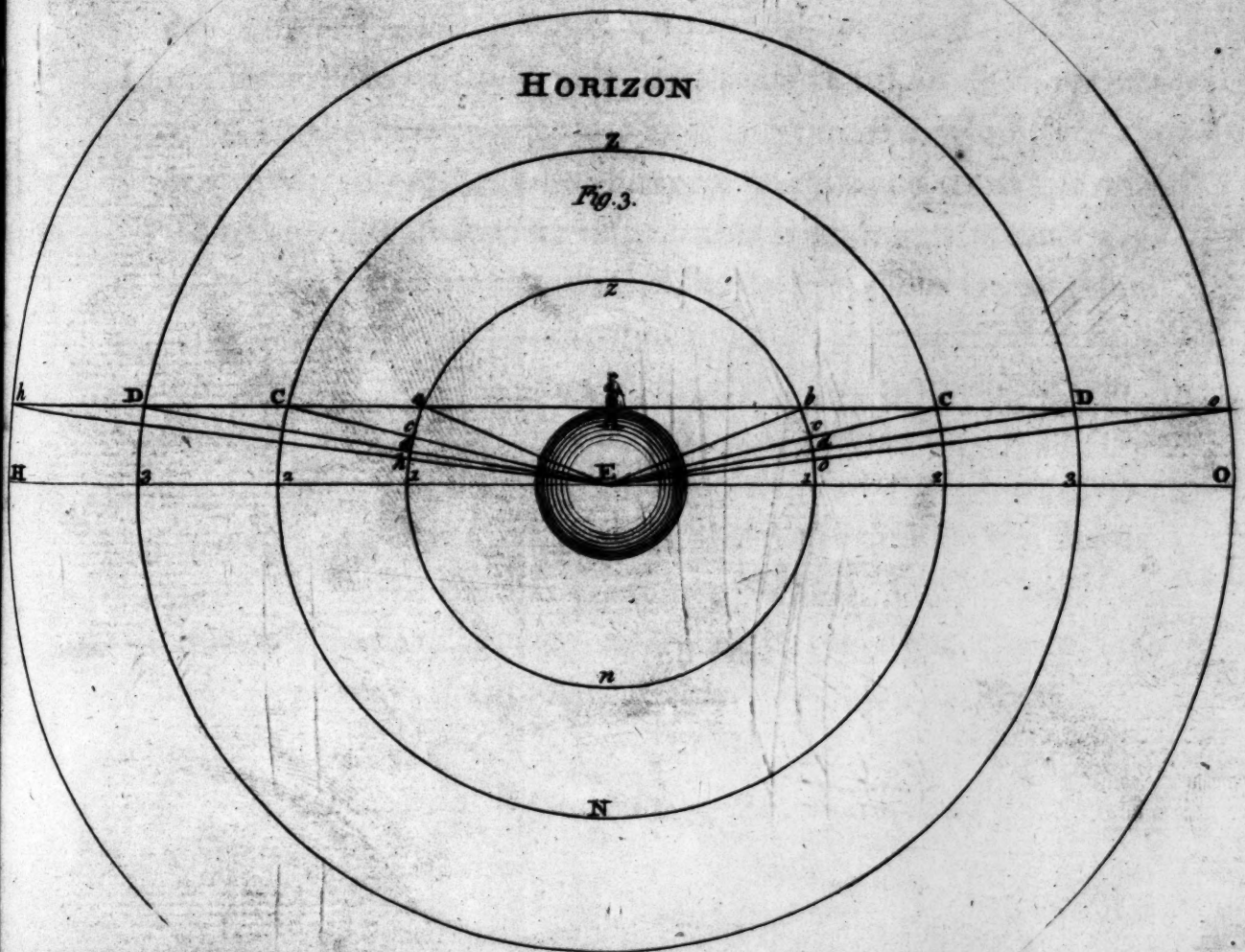


Fig. 3.

is great difference between an object placed at 1, on the true horizon, and another at *a* or *b* on his apparent horizon; yet this difference is perpetually decreasing, as the distances of objects increase. The object C at the distance 2, being seen from E much nearer 1. The object D at the distance 3 nearer still to 1. The object *b* or *o*, at H and O nearer still. It is but adding yet further distances, and the spaces on the line *a*, *c*, *d*, *b*, 1, will approach nearer and nearer, till at length they become totally insensible: So that with regard to objects at very remote stations, A and E will have precisely the same horizon.

Z being vertical to A is the *Zenith*, N being centrically under him is *Nadir*.

In conformity to this principle, it is usual to calculate all appearances of the heavenly bodies as if they were viewed from the centre of the earth, and there were no distance from the centre to the circumference: [*i. e.* that the earth were *a point* only.] For though to its inhabitants this globe be large and capacious, yet when compared to space around it, it shrinks into nothing. Therefore when the sun is said (or represented) to be in any station, we must take with us the idea of his being so as seen from the centre of the globe. The same of the planets: though in nice observations, the diameter of the earth has its effect; and comes under the principles of PARALLAX (especially with regard to the moon), and is one way of calculating their distances, and sizes.

PLATE

PLATE II.

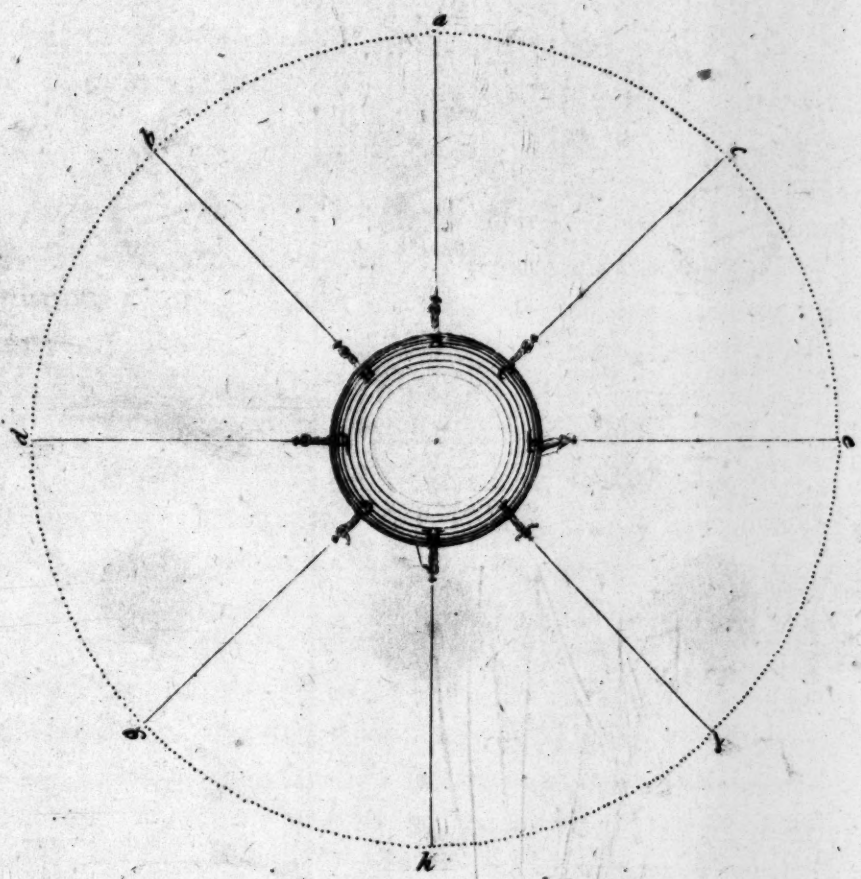
ANTIPODES AND HORIZON.

THE plane of our HORIZON continued to the Heavens, divides them into two *hemiſpheres*; one viſible, the other inviſible, being hid from us by the interpoſition of the earth. As in this plate, to the figure A his viſible horizon is *d, a, b, c, e*, his inviſible *d, g, h, f, e*. To the figure B his viſible horizon is *g, d, b, a, e*, his inviſible *g, h, f, e, c*, and ſo of the other figures. Alſo the figures A and H have *oppoſite* horizons; what is viſible to one, being inviſible to the other. When therefore we ſay, ſuch an object is *above* or *below* the horizon, we are to underſtand the expreſſion relatively, *i. e.* with reſpect to ourſelves: ſince what is above to one, is below to another; as the point *b* is, to A above the horizon; to C at the horizon, and to E, below the horizon. The ſame idea applies to any other point, as ſeen from other letters.

This figure explains and juſtifies the idea of ANTIPODES; for here we ſee that the feet of the inhabitants of the earth are reſpectively turned to their *oppoſites* on the ſurface of the globe, without any fear of their falling from it; being ſecured by the attraction of the earth, which acting equally all around its circumference, leaves no vacuity where its power is not operative. Now if the ſame power exert itſelf all round the globe, by parity of reaſon the ſame effects will take place every where, and therefore A has no reaſon to fear for his ANTIPODES H, till he feels himſelf looſened from the earth, his feet without ſupport, and himſelf *falling upwards* into the ſky.

PLATE

ANTIPODES, *and* HORIZON.



SEASONS.

Fig. 1

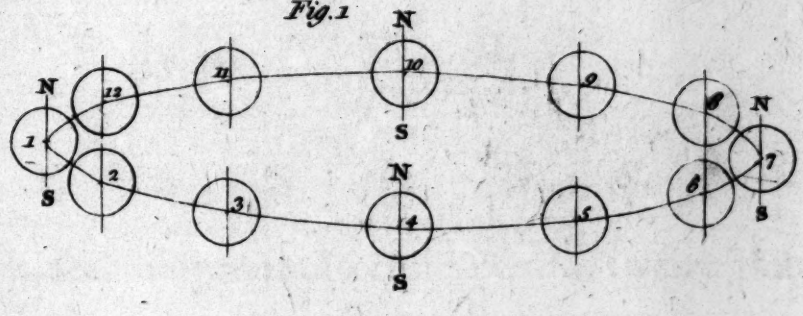


Fig. 2

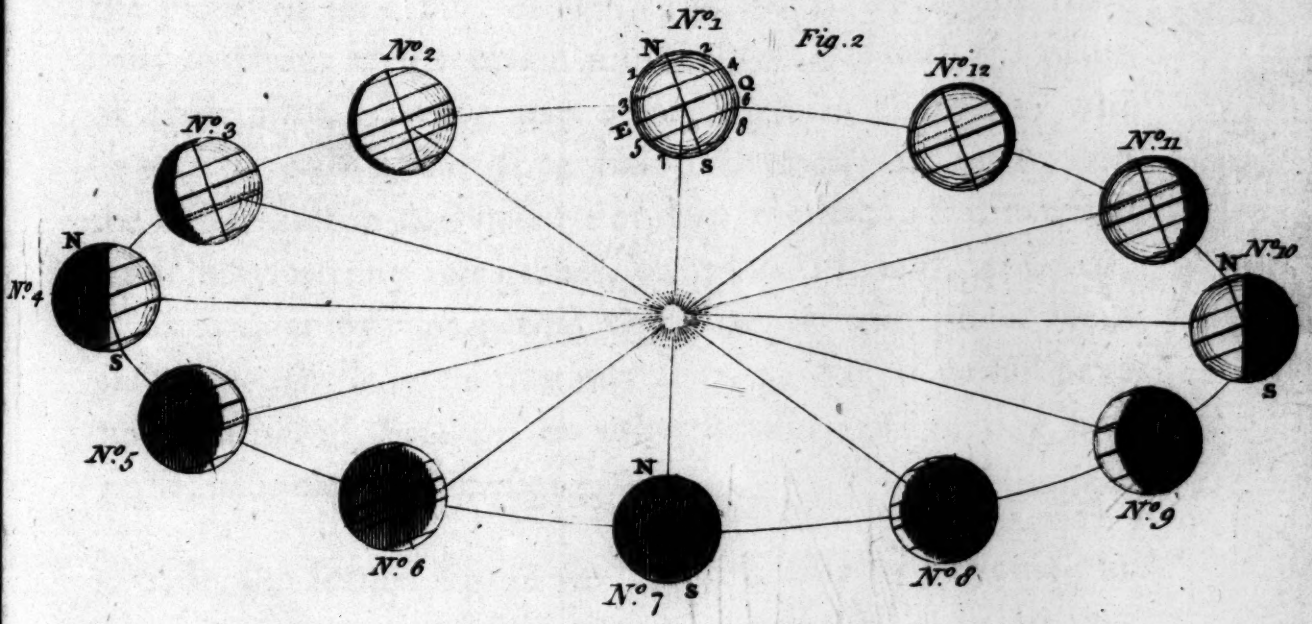


Fig. 3

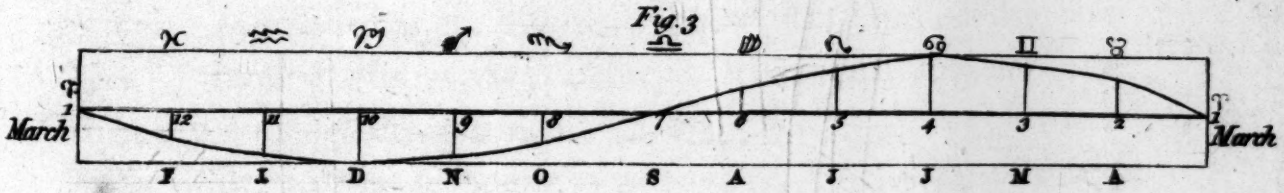


PLATE III.

SEASONS.

Fig. 1. repreſents, according to the Lecture, p. 134, twelve globes placed round the ſun; the axis of each perpendicular to the plane of its orbit: of conſequence, if we admit their daily rotation, that rotation muſt be *coincident* with the plane of their orbit. Every part of each globe, therefore, will be exactly half a day (*i. e.* half a rotation) in light, and the other half in darkneſs; nor does the ſmalleſt difference occur between any two globes, but as well 1, as 7, 4, as 10, 6, as 12, enjoys perpetual equinox. If one globe were placed *ſucceſſively* in the ſtations 2, 3, 4, &c. it would have no variation of Seaſons, or other viciſſitude than day and night, as is clear by the figure.

Fig. 2. In the former figure we ſuppoſed what is not true; in this figure we attend ſolely to fact; for inſtead of being upright, the axis of the earth, N S, appears inclined throughout the whole of theſe figures; in which, preſerving the idea of twelve globes, we obſerve, that the *oppoſites* are ſtrongly contra-diſtinguiſhed. Except No. 1 and 7, which differ only, in that to one it is noon-day, to the other midnight.

No. 1. N the North Pole, S the South Pole; 1, 2, the arctic circle; 3, 4, the tropic of Cancer; E Q, the equator,

tor, or line; 5, 6, the tropic of Capricorn; 7, 8, the antarctic circle. [The ſimilar lines on the other numbers correſpond to thoſe on this figure.] The ſun appears to be vertical in the equator, making equal night and day throughout this globe; as appears by inſpection. We ſuppoſe a rotation from 1 to 2, 3 to 4, E to Q, 5 to 6, 7 to 8.

No. 2. In this globe the North Pole loſes its diurnal ſhare of light, and the South Pole gains it; becauſe the verticity of the ſun is not in the equator, but ſouthward of it, being now at the dotted line, nearer the tropic of Capricorn.

No. 3. The ſun's vertical ſtation yet nearer the tropic.

No. 4. In this globe the North Pole is totally deprived of the ſolar beams: the daily rotation of the globe bringing no part of the arctic circle into his light, while the South Pole enjoys his continued influences.

No. 5. The ſolar vertical ſtation nearer the equator.

No. 6. The ſun ſtill nearer the equator.

No. 7. The ſun in the equator *(equinox)*.

No. 8. The ſun above the equator, advancing northward.

No. 9. The ſame progreſs more apparent.

No. 10. The ſun in the tropic of Cancer: the North Pole illuminated during the whole rotation: the South Pole conſtantly in darkneſs. The ſame circumſtances attend all places in each hemiſphere, according to their diſtances from the pole.

No. 11. The ſun declining toward the equator.

No. 12. The ſun very near the equator.

Obſerve

Obſerve the *oppoſitions* of theſe globes; No. 1. and 7. are alike, except that to one it is day, to the other night. No. 2. The ſun below the line. No. 8. The ſun above it. No. 4. The North Pole dark, conſequently winter there and ſummer in the ſouth. No. 10. The North Pole light, conſequently ſummer there and winter in the ſouth.

The ſame would be the ſeaſons, &c. of a ſingle globe, progreſſively in the ſituations 1, 2, 3, &c. as appears by the figure.

Fig. 3. The plan of the ſolar verticity, progreſſively advancing and receding on the ſurface of the globe. 1. The ſun at ♈ in the equator; 2. 3. the ſun advanced northward; 4. the ſolſtice; 5. 6. the ſun returning ſouth; 7. the ſun again on the line, going ſouth; 8. 9. 10. the ſouthern ſolſtice; 11. 12. the ſun returning to the line 1. ♈. The letters below the figure indicate the months of the year.

Though it has been ſaid, the inclination of the earth's axis is conſtantly the ſame, yet this excludes not ſome ſmall variation; the attractive power of the ſun and moon ſlightly diſturbing it at the ſolſtice, the poles *nodding*, as it were, a few ſeconds, and returning to their places in about 18 years. There is alſo a motion which *decreaſes* gradually the obliquity of the ecliptic, which formerly rather exceeded 23 : 30′; but now is leſs nearly 2′. The equinoxes alſo do not happen in any ſucceeding year *preciſely* to a moment as the year before; but have a retrograde motion of about 50″ yearly, ariſing from the attraction of the celeſtial luminaries. This motion completes a revolution in about 25,000 years.

To ſuch diſturbances, though inſenſible to its inhabitants, are ſubject the firmeſt principles of the terreſtrial motions!

PLATE IV.

LENGTH OF DAY AND NIGHT.

THESE three figures ſhew more correctly (being larger) the principal effects ariſing from the changing ſtation of the ſolar verticity, to any particular place, as LONDON (L). The daily rotation of the earth ſuppoſed 1 to 2, 3 to 4, &c. The references are alike in all the figures. N the North Pole, S the South Pole, 1, 2, the arctic circle, 3, 4, the tropic of Cancer, E Q, the Equator, 5, 6, the tropic of Capricorn.

Fig. 1. The ſun in its higheſt northern latitude (the tropic of Cancer); the North Pole wholly enlightened. LONDON (L) by much the greater part of the twenty-four hours enjoying the light of the ſun; and when by the rotation of the globe brought to the ſhadowed part of it, rather *dipping* into, than remaining in it. The ſemi-diurnal arc being 3 *a*, 8 hours 16 minutes; the ſemi-nocturnal arc *a* 4, 3 hours 44 minutes.

Fig. 2. The Sun in the equator; the ſemi-diurnal arc E C, equal to the ſemi-nocturnal arc C Q; conſequently the *equinox*.

Fig. 3. the reverſe of fig. 1. The ſun highly ſouth, L enjoys but ſhort day-light, being quickly brought again into the ſhadow: the day is now the length of the night (7 hours 28 minutes) in fig. 1. and the night the length of the day (16 hours 32 minutes).

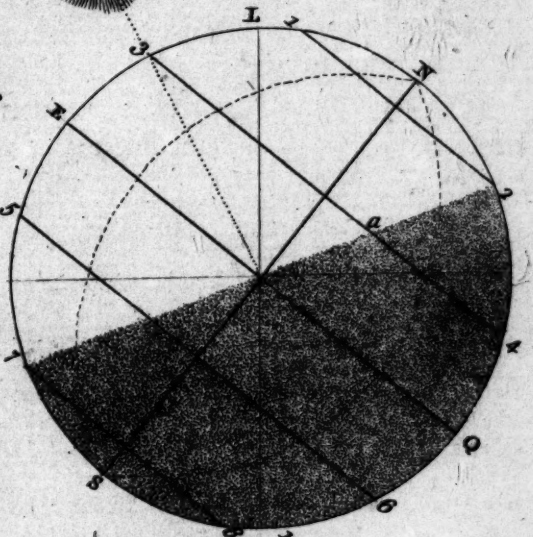
Whenever the ſun comes in the daily rotation to the line N S, it is *ſix o'clock*; which in fig. 1. is long before the ſhadow begins; in fig. 2. is exactly at the beginning of the ſhadow; in fig. 3. is immerſed conſiderably in the ſhadow.

PLATE

Lecture VII: Plate IV.

LENGTH of DAY and NIGHT.

Fig. 1.



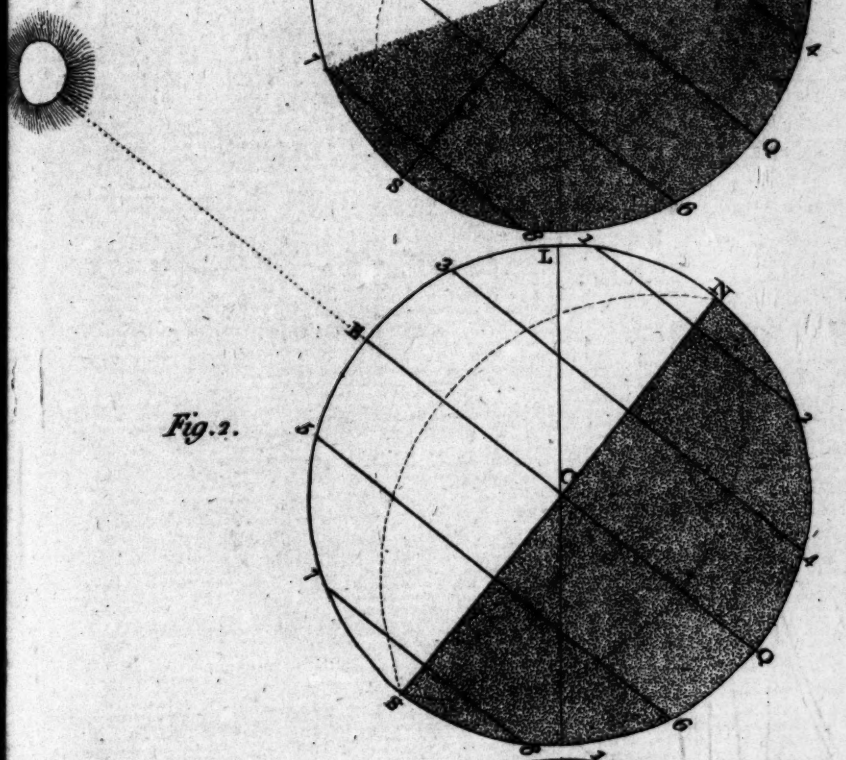


Fig. 2.

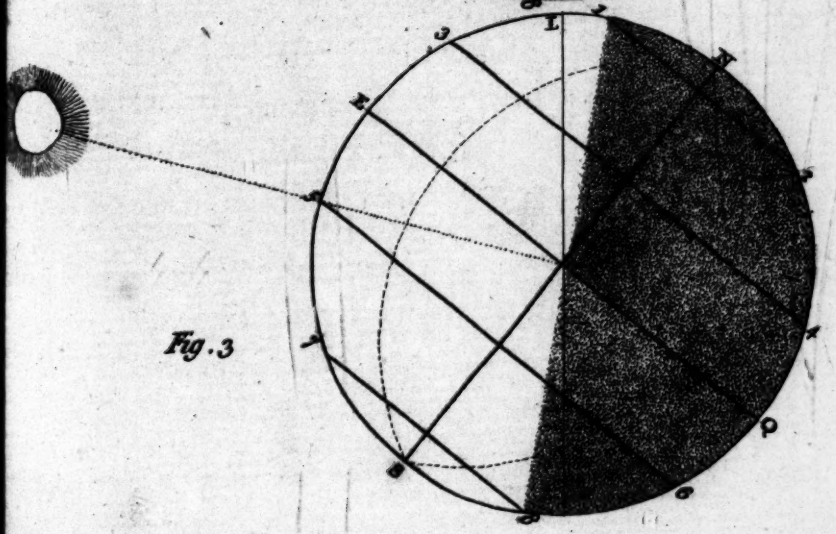


Fig. 3

ROTATION of the EARTH.

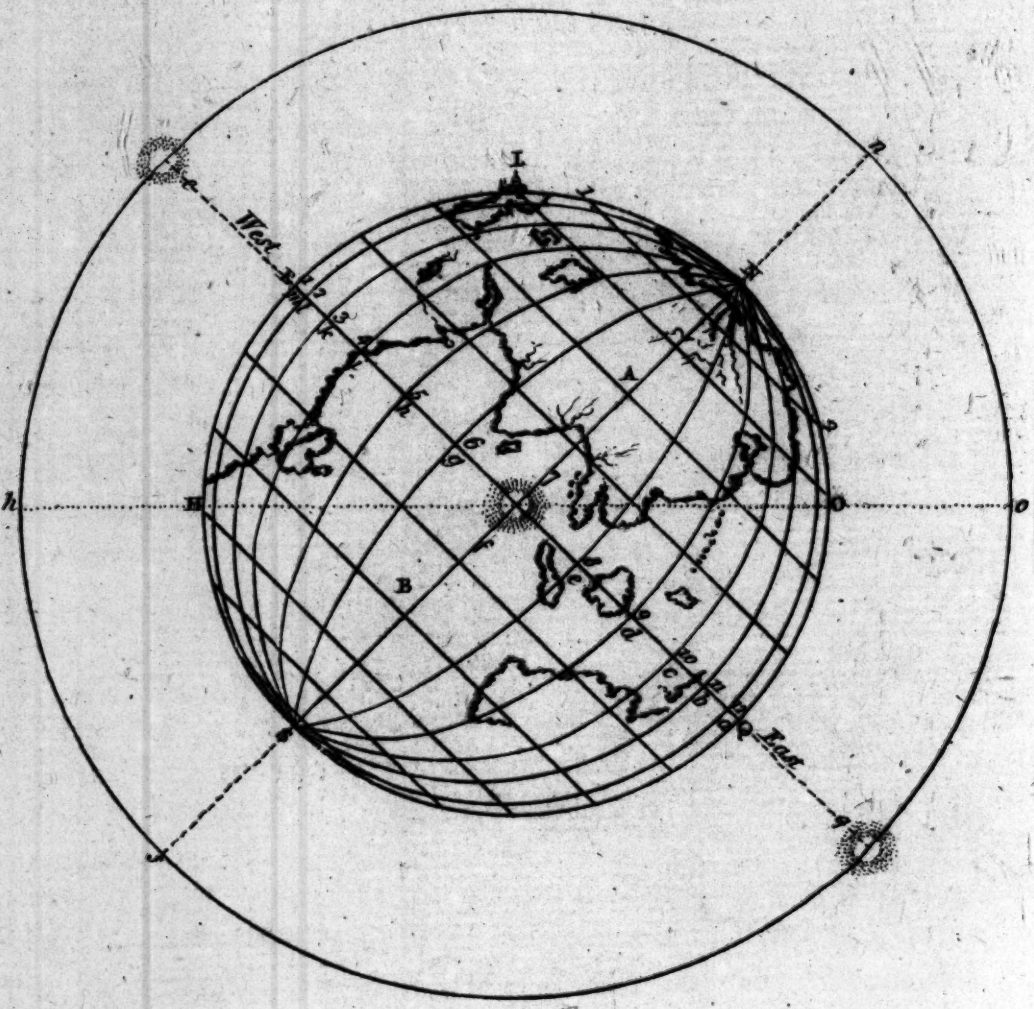


PLATE V.

DAILY ROTATION OF THE EARTH.

THIS plate exhibits the courſe of an equinoctial day. The earth's rotation *from* Weſt *to* Eaſt, in the order of the *figures* 1, 2, 3, 4, &c. Or, ſuppoſe the line 11. takes in an hour's time the place of that marked 12, the line 10 the place of 11, and ſo on, then 1 becomes 2, 2 becomes 3, 3 becomes 4, &c. and all in ſucceſſion will point at any object ſituated above and beyond the rotation. Such an object therefore will, to the inhabitants of the globe, advance in a *contrary* direction; as *a*, *b*, *c* *d*, &c. according to the order of the *letters*. If we ſuppoſe a circular line; as that which goes round the figure, to be elevated *over* it on the equator E Q, any fixed object in that line, would *ſeem* to advance in the order of *the letters*. We admit this object to be the ſun.

Wherever the ſun is vertical it is noon. Suppoſe him vertical at Q, it is forenoon to *a*, *b*, *c*, *d*, *e*; morning to *f*; night to all beyond. As *f* gradually turns to him, it is at *f* noon, forenoon to *g*, *h*, *i*, *k*, *l*, day-break to *m*, and night to all beyond: and it is afternoon to *e*, *d*, *c*, *b*, evening to *a*, night to all beyond. As the earth continues her rotation, the ſun *ſeems* to advance to *e*, where it is noon to E, afternoon to *m*, *l*, *k*, *i*, *h*, *g*, evening to *f*, night to all beyond.

The figure ſhews, that when it is noon, evening, or night, to any ſpot under the line E Q, it is the ſame time of day to all places north or ſouth of that line: As when the ſun is on the mid-day *(meridian)* line, *f* 7, it is not only noon to *f* and to 7, but alſo to A and to B; and it is equally day-break to H E and L: and ſo of all other *meridians*.

PLATE

PLATE VI.

Fig. 1. ſhews various lengths of the ſhadow from any object, as occaſioned by the ſun at his different ſtations in the ecliptic. S his winter ſtation; the ſhadow prolonged on a pavement to 3: S 2 the equinox; ſhadow ſhortened to 2: S 3 the ſummer ſolſtice; the ſhadow approaching to the perpendicular of its object at 1. *a*, *b*, *c* ſhew the ſame effect ſuppoſed to be noticed on a wall or other perpendicular.

Fig. 2. Shews that the ſpace is much leſs between thoſe rays of light, &c. which fall immediately *perpendicular*, as 1, 2, than between thoſe which fall *obliquely*, as 3, 4: conſequently fewer rays, and thoſe leſs powerful, fall on any equal ſpace on the lower line than on the upper. This effect would be greater ſtill at a greater obliquity, as 2, 3.

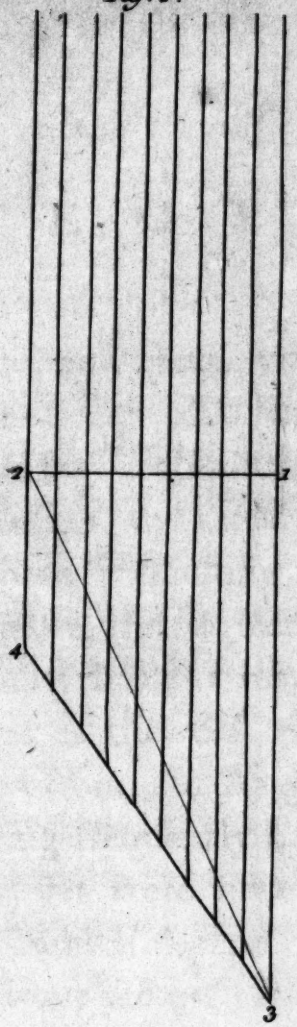
Fig. 3. ſhews, that if the rays of light fall nearly direct 1, 2, and are reflected in the ſame angle 2, 3, from whence they are again returned 3, 4, a much greater number will fall on a given ſpace, and with a greater effect, than when, as in fig. 4, the angle at which they fall is greater 1, 2, and when fallen they rebound farther 2, 3, and are reflected again to ſo wide an angle as 3, 4.

This plate explains the reaſoning introduced in the lecture page 133.

LEC-

SEASONS.

Fig. 2.



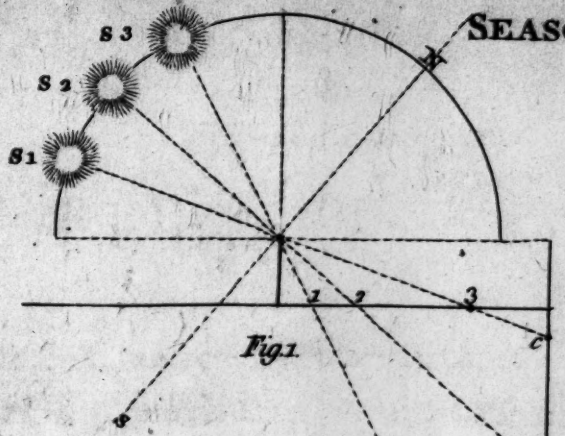


Fig. 1.

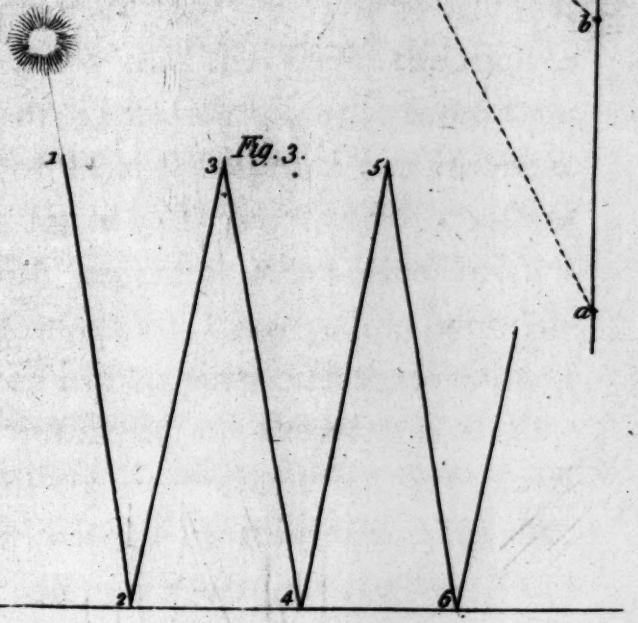


Fig. 3.

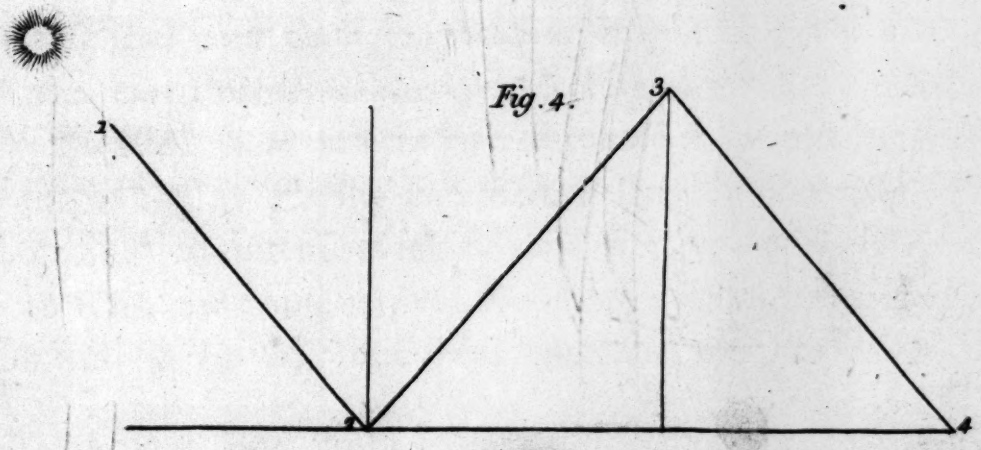


Fig. 4.

LECTURE VIII.

IF but now and then, we were favoured with opportunities of noticing ſuch intereſting particulars as are conſtantly occurring around us, our curioſity might be excited, and our attention awakened; not that the facts themſelves would be more intereſting, or more uſeful, but more rare. In human nature, the neglect of what is common is a frequent failing: novelty has charms, for which we forſake conſtant utility. This is the caſe with regard to our notice of benefits received from our ATMOSPHERE: I have often wondered at it, having frequently been in company among perſons of talents, who yet were little informed of the nature of that medium, on which depend all the enjoyments of ſight, and perhaps of all our ſenſes. But we are at this time, LADIES and GENTLEMEN, diſſenting from popular inattention, and deſirous of acquiring information on this important article.

Let me firſt lead your thoughts to what might be our ſituation, had the earth no atmoſphere encircling it; what a deſert! what a waſte! The ſun in the firmament would ſeem like a fire in the night, glaring and fierce, ſtrongly contraſted on a back-ground of intenſe black, overpowering indeed the ſtars cloſe to him, and thoſe only. No others would "hide "their diminiſhed heads," but ever acccompany his daily appearance:

appearance: ſuch would be the ſcene in the heavens! On earth, we ſhould be overwhelmed with the reſplendence of that diminutive portion immediately adjacent to us; while, on either hand, at but a little diſtance, reigned obſcurity and night; farewell the gentle declivities of rounding bodies, farewell reflex lights, intermingling colours, the infinite variety of compounded tints, the delighting diverſity of brilliant harmony! Behold, inſtead, light, inſupportably ſplendid! and darkneſs, the ſhadow of death! Farewell the voice of muſic reſounding through the grove; farewell reſpondent echo, if not the ſprightly vivacity of cheerful converſation; farewell gentle warmth, if not heat; or gentle coolneſs, free from freezing cold.

But as my deſign at preſent is rather to conſider the viſible effects of the atmoſphere; I propoſe the following thoughts for your attention.

The atmoſphere reaches in extent over our heads to a very conſiderable diſtance, perhaps two or three hundred miles or more; but at its extreme height is ſo very thin, attenuated, and rare, as to loſe itſelf inſenſibly in æther. We ſhall therefore only aſſume its height from the earth, where it is found to be of any uſe to us, *i. e.* about forty-five miles; at which diſtance it is ſenſible by the effect of light.

The atmoſphere is TRANSPARENT, whereby we are permitted to view an infinite number of ſhining bodies *through* it, whoſe light paſſes into this medium, and ſo to our ſight: yet, compared with the adjacent æther, the atmoſphere is DENSE and compact, indicating, as it were, the approach to

a ſolid body, by which denſity it attracts the rays of light paſſing near it, and inflects them for our uſe, as one may ſay, before they deſigned it; which I explain thus: all rays, in a uniform medium, paſs in ſtrait lines (the æther is a uniform medium); but paſſing from one medium into another, they are acted upon by this ſecond medium, according to its nature. If it be thinner than the medium they quit, they riſe upwards; if it be denſer than the medium they quit, it attracts them to itſelf, and they bend downwards. Such is the nature of the atmoſphere; it attracts the paſſing rays of light, and bends them down to earth, long before they would ſtrike it, if their courſe was not thus diverted. When the ſun is below the horizon more than eighteen degrees, his rays ſhoot into empty ſpace; but when at that point, the atmoſphere feels the welcome viſitants, and directs their courſe, by its refractive power, down to the ſurface of our globe: this is the firſt point of twilight; which, as the ſolar rays ſucceed each other, and increaſe in quantity, iſſues at length in morning.

I ſhould obſerve, that TWILIGHT varies according to the ſtate of the atmoſphere; ſo that ſometimes, when the ſun is more than eighteen degrees below the horizon, his rays are inflected. For if the atmoſphere be elevated by heat, it may ſooner catch the ſolar rays; if it be depreſſed by cold, it will be later ere it feels their influence. On this circumſtance depends the duration of twilight; and this renders twilight longer in the evening than in the morning, and in warm weather, than in cold.

If it be advantageous to us, who but for a few hours have loſt the revolving ſun, to be advertiſed of his approach; what muſt be the ſenſations with which thoſe receive the welcome harbinger, the firſt dawn of twilight, who have been long deprived of the glorious luminary! who have abode for many weeks in darkneſs, without one cheering beam to gratify their deſiring eyes; 'tis almoſt a renovation of life! Providence has therefore kindly ordered that their twilights ſhould be lengthened in proportion; ſo that at the beginning of February, when twilight is with us about two hours, with them it is nearly double that time: the earneſt of future day!

My auditory will remark for themſelves, that the evening twilight correſponds *inverſely* with what I have deſcribed of the morning. As the ſun declines, his ſplendour gradually diminiſhes, not harſhly, not ſuddenly, but by gently withdrawing, prepares us for its total abſence. The benighted traveller mourns not his bewildered way; loſt though near his home! "The lowing herd winde ſlowly o'er the lea," without apprehenſion of all-enveloping darkneſs.

Thus I think I have treated of the firſt part of the ſervice rendered us by the atmoſphere; its refraction of the rays of light: —We will next conſider its reflection of them; for we are not to ſuppoſe, that all the light which ſtrikes the atmoſphere, reaches our eyes exactly as the atmoſphere received it: by no means; but it ſeparates the rays received from the ſun, as any other medium properly interpoſed would do. Some it reflects back again in every direction, others it tranſmits, and they paſs through it. Hence ariſes all the variety which decorates

the ſky; " the firſt break of day is a cold light in the eaſt;— this by degrees is tinged with purple, which grows redder and redder, till the purple is loſt in orange, the orange in yellow, and, before the ſun is two degrees high, the yellow is changed to white. Invert this order, it is the approach of evening." Can expreſſions more juſtly deſcribe the priſmatic colours! (of which elſewhere) the principle is clearly this: at a certain angle made by the ſun with the atmoſphere immediately around us, it reflects the purple rays of light, and tranſmits the others: at a leſſer angle, it reflects orange, and then yellow, always underſtood to tranſmit the others; but when the rays of light paſs directly to our eyes, the whole is white. This idea will occur hereafter.

We ſuppoſe the atmoſphere to be replete with light; and now it tranſmits to us thoſe rays, which ſtrike our eyes with the moſt lovely blue: the happy medium between oppreſſive darkneſs and intolerant light, the ſplendid canopy of Heaven! For the celeſtial azure is not produced by any agency remote from our earth, it is not the effect of diſtance, and the offspring of etherial nothing (of nothing nothing comes), but is ſimply the production of our own atmoſphere, and the effect of cauſes near ourſelves. Our atmoſphere reflects blue; that of the planet Mars is ſuppoſed to appear to its inhabitants red; but whether the ſuppoſition be juſt, or whether red be to them the moſt pleaſing of colours, is not for us to determine. The atmoſphere, we ſaid, is replete with light: this it retains, not for itſelf but for its inhabitants; all around it diſtributes this important article, in every direction,

tion, freely, abundantly, enabling the light to viſit every part, and by rebounding, now here, now there, to render viſible every object, near or diſtant.

We have taken the height of the atmoſphere at about forty-five miles; we will, if you pleaſe, divide this height into *nine* parts for readineſs-ſake, each five miles——The higheſt is exceeding thin and weak, the ſecond ſomewhat ſtronger, the third ſtronger ſtill, till at the bottom, *i. e.* adjacent to the earth, the laſt ſpace is in compariſon very much compreſſed—Or invert this order; next the earth the atmoſphere is not only more ſenſible of the attraction of the earth, but alſo is preſſed by the weight of the ſuper-incumbent diviſions (not to mention its load of vapours of every kind, ariſing from the earth); conſequently it is more denſe; the ſpace next above, being leſs attracted and leſs preſſed, is leſs denſe; and ſo of the whole. It follows, that a ray which enters at the thinneſt part, and is thereby converged downwards, is perpetually paſſing into ſtill denſer and denſer mediums, whereby it is bent more and more, ſo as to be conſiderably incurvated ere it reaches our eyes. Of courſe, as we ſee luminous bodies only by ſuch rays, they are not in fact where they appear, but allowance muſt be made for the refractive bending of the rays of their light. This refraction is greateſt at the horizon, and leaſt or nothing in the zenith.

In conformity to this train of reaſoning, I have now to propoſe another important benefit, received from the intervention of an atmoſphere. If at the horizon it elevates the heavenly bodies, ſo it does alſo the horizon itſelf; it enlarges and

extends

extends our view of objects ſituated on the horizon, ſo as to enable us to ſurvey a diſtance very diſproportionate to our geometrical height above the level of the ground we tread. This, on land, enables us to diſcern the melting diſtances, and the wide-ſpread landſcape: We deſcry from afar our friends, or our foes; we anticipate the joys of meeting, or we prepare for perſonal protection, and ſelf-defence; or, travelling to a diſtant city, we behold remotely our propoſed reſidence, and direct our way by the readieſt road. To this property of the atmoſphere were indebted the ten thouſand Greeks, who, with Xenophon at their head, retreated from Babylon; after many a toilſome march, after many a bloody combat, and much oppoſition, arrived at length on a mountain's brow, whence they might ſurvey the far-diſtant proſpect, they filled the echoing air with ſhouting, the ſea! the ſea! whoſe friendly waves they knew would tranſport them to their native home. To this property of the atmoſphere is indebted the venturous navigator, who hereby notices diſtant dangers on foreign ſhores; and he, who ſeeing the Centaur ſink, had leaped from the foundering ſhip, had paſſed many days and nights in an open boat, till exhauſted nature ſupported not want and fatigue, his "ſwearing fit of joy" had given place to ſilent deſpair, had not this property of the atmoſphere elevated in the air the mountain of Teneriffe, and afforded a mark to which to direct the ſhattered prow.

The proportion in which the atmoſphere elevates objects in a ſmall ſpace, is determined by obſervation: for this purpoſe Mr. HAWKSBEE, by appointment of the Royal Society,

fitted an apparatus, by which he found an object was *in vacuo*, lower by ten feet and a quarter, in a diſtance of two thouſand five hundred eighty-eight, than in open air; upon condenſing the air, by injecting a double portion, the object was elevated twice ten feet and a quarter; upon letting out the ſuperadded air, the object deſcended gradually to its true ſtation, as the air returned to its atmoſpheric ſtate.

Allowances muſt be made in this experiment for the glaſs through which the object was ſeen, and for other particulars; enough is proved by it, to demonſtrate that the atmoſphere has very ſtrong refractive powers, by which it elevates objects; eſpecially thoſe at a diſtance, and ſeen through its groſſeſt medium; *i. e.* that track of it next the earth.

That the atmoſphere next the earth is of conſiderable denſity, I think appears from the principles of aerial perſpective, which having formerly treated, I ſhall now decline: with a ſingle obſervation, that although this medium is probably pellucid and colourleſs, yet as it reflects blue rays, we may call it blue without offence; eſpecially, as this is the colour it imparts to all objects ſituated at ſufficient diſtances to render its effects ſenſible; and methinks it is a curious ſight (not uncommon in Italy), to ſee a diſtant mountain covered with ſnow, in parts (its ſhadows) blue, while the ſun, by ſhining on the other parts, renders them red.

Hitherto we have treated the atmoſphere as a ſimple homogeneous medium; but perhaps it may contribute to facilitate our conception of its powers, if we conſider the great proportion of watery vapours always floating in it, and more or leſs intimately

intimately united with it; ſuch as ſteams from rivers, lakes, and ſtanding waters; from the earth itſelf; from perſpiration of animals, plants, &c. &c. Now, as water is a much ſtronger refractor than air, it proportionately increaſes the aerial effects. A very remarkable proof of this poſition is given in the Philoſophical Tranſactions, No. 212, where we are told, that from Greenwich looking over the point of the Iſle of Dogs, that meadow only is to be ſeen at low water; but at high water, not only the meadow oppoſite on the other ſide the river, but alſo the cattle feeding on it, are rendered diſtinctly viſible, by the ſtronger refraction of the humid and watery air now attending the courſe of the river.

The atmoſphere is the cauſe of heat; that is to ſay, heat is, by it, collected, diſperſed, and rendered active; or by heat it is agitated, and rendered ardent (of this in its place).

I beg leave now to ſolicit your attention, LADIES and GENTLEMEN, to the ſimplicity of thoſe principles by which Providence produces ſuch and ſo many admirable effects; mankind unite many wheels and ſprings, many principles to attain one effect; Omnipotence produces from one principle many effects; each ſeemingly independent of others, yet all reſulting from one leading appointment. View thoſe azure ſkies, they ſeem the arch of the ſtarry firmament; but they only *ſeem*, the ſtarry firmament is—black (*i. e.* colourleſs). What we take for heaven, is in fact the mantle of the earth, at leaſt it is the canopy raiſed around it. How inſignificant in themſelves, a few ſmall bubbles of air and water! but not when directed by ſuperior ſkill; then they ſhall be uſeful,

elegant, decorative, then they ſhall gradually prepare us for light, light for us; ſhall divert its progreſs, and diſperſe it around us; ſhall become the very example of placidity and cheerfulneſs, the delight of the eye! uniform, ſo far as uniformity produces grandeur and majeſty; various and diverſified, ſo far as variety promotes delight. Free from the glare of offenſive yellow, or the melancholy of ſombrous black; from terrible red, or diſmal brown; yet occaſionally exhibiting every variety of tint, every changing refulgence of colour.

Obſerve the various duties of the atmoſphere, in the various parts of the day. It firſt gently introduces the light; then it ſpreads light all around; and laſtly gently withdraws the light, preventing darkneſs from ſurpriſing us unprepared. Nor is it leſs deſirous of imparting pleaſure, when the cool moonlight ſhews its cerulean tints, or the ſtar-blazing heavens ſtream ſprightly luſtre.

Nor is the atmoſphere deficient in the various duties of various ſeaſons: in Spring its lengthening light refreſhes and exhilarates the ſpirits; in Summer, it prolongs the evening walk, and, after the ardent heat of day, it invites enjoyment ſalubrious and pleaſant; in Autumn, the huſbandman finds its advantage, and it lengthens out the reaper's daily taſk: but when bleak winter covers the earth with ſnow, or binds it with froſt, the cheerful hearth, the ſprightly blaze, is the refuge of man; of what value then were long-continued twilight? The uſes too of the atmoſphere, in the different climates of the world, deſerve our notice; beneath the line, ſultry days excite deſires for cooling night, here is a

twilight of an hour; at the poles, twilight prolongs all-cheering day, here is a twilight of many hours; every glimpſe of light is valuable here, let the poles enjoy it by refraction.

We ſhall now conſider the atmoſphere, as contributing very greatly to the enjoyment of other ſenſes of human life: its effect indeed ſeems not very powerful in the articles of taſting or feeling, or at leaſt, it is not very evident in what manner it contributes to thoſe ſenſations; but the atmoſphere is excluſively the medium of ſound, and if we were deſtitute of ſuch a ſurrounding fluid, we ſhould neither enjoy the cheerful voice of melody, nor the ſocial endearments of friendſhip: converſation, inſtructive or delightful, would be unknown, joyful expreſſion, or anxious ſolicitation would never thrill in the awakened ear; no nor the tender accents of liſping infancy, or the nobleſt inductions of manly reaſon.

Sound is an idea excited in the mind by means of the auditory nerves, which receiving impreſſions from the external air, communicate correſponding impreſſions to the brain. In the air itſelf, ſound is propagated or diſtributed from place to place, by means of certain tremors or vibrations which originate in the ſonorous body. An inſtance may explain this idea; obſerve the vibrations of a large bell ſtruck by its clapper or a hammer; theſe produce correſpondent vibrations in the immediately ſurrounding air; from this ſurrounding air they are tranſmitted to the air around that, through this to other air more diſtant, and ſo on, ever decreaſing in ſtrength of tone, as increaſing in diſtance,

diſtance: much as the circling waves which ruffle the ſmooth ſurface of a ſtanding pool, when you throw a pebble into it, are firſt ſtrong and clear, but gradually enfeebled as they enlarge in dimenſions, they decreaſe in ſtrength, till their impulſe is too ſmall to move the quieſcent fluid.

Water is capable of receiving theſe motions on ſeveral parts of its ſurface at once, and the circular waves in their courſes will croſs, and, as it were, go through each other, notwithſtanding their reciprocal reſiſtance: thus, ſounds from all parts may reach the ear at the ſame time, and, according to their force, they ſuggeſt the idea of diſtance. The idea of *direction* (*i. e.* from what quarter they come) ſeems to be acquired by the mind in conſequence of much attention, and to be learnt by frequent remark and correction.

It is a mighty pretty experiment, performed by putting a little bell under the exhauſted receiver of an air-pump, in which ſituation it makes no ſound; I mean, that however the clapper, by ſtriking the ſides of the bell, may cauſe them to vibrate, yet the ſpace around the bell being void of air to receive thoſe vibrations, they are totally impotent, for want of a medium to tranſmit them. In condenſed air ſound is proportionately ſtrengthened. We ſhall have occaſion to recur to further principles on this article when inveſtigating the ſenſe of hearing; I therefore ſhall now only remark, that the atmoſphere tranſmits ſound through very great diſtances, but if any impediment be interpoſed, it returns the agitated waves from ſuch impediment; and this return of ſound we call an *echo*.

The

The diſtance to which ſound may be carried by the atmoſphere, may well be ſuppoſed proportionate to the magnitude of the ſonorous body, to the intenſity and force of the ſtroke acting on ſuch body, and to the ſtate of the atmoſphere itſelf, whether clear and pure, or vaporated; to which we muſt add, the courſe and ſtrength of the wind; ſince that may either accelerate, or retard the wave of ſound, either prolong or ſhorten it. Sound has been frequently heard fifty, or ſixty, or eighty miles; but Dr. Hearn, phyſician to the king of Sweden, tells us, that the ſound of the bombardment of Holmia, A. D. 1658, was heard an hundred and eighty miles; and ſome have thought, the guns at the action of La Hogue were heard two hundred miles.

The immenſe variety of proceſſes conſtantly carrying on in the atmoſphere, the numerous objects which occur to divert ſound from its courſe, and to impede its progreſs, may very much leſſen its effects from what they would be in a medium ſtill, pure, and free. This ſeems confirmed, by the ſtrength of the voice in caverns and vaults, where the air is at reſt, and by the diſtance at which the voice may be heard on a ſmooth river: perhaps I may add, the inſtance of a countryman, who being employed to dig a deep pit, was frightened from his work by dreadful noiſes! which proved to be thoſe ariſing from the trotting of a flock of ſheep at two miles diſtance, but tranſmitted to him by ſome ſubterraneous conveyance.

The principles of echoes are not unlike thoſe of reflected light; they are reverberations or returns of ſound from ſome

body

body againſt which, what I may term the rays of ſound, ſtrike, and unable to paſs through it, are beaten back, and returned. This returning may ariſe from many kinds of objects, from a wall, from a hill, or if other impediments to the progreſs of ſound be wanting, the atmoſphere furniſhes clouds, which often create echoes to great ſounds. There are many very curious echoes mentioned by authors; ſome natural, ſome artificial; in ſome, the ſound is repeated twenty, thirty, even fifty times, ſome repeat ſyllables, and ſome words, or ſhort ſentences; this is eaſily accounted for on the principles juſt hinted.

We ſhall turn our thoughts for a moment to the uſes of the atmoſphere as they regard the ſenſe of SMELLING. We may conſider a flower, or other odoriferous body, as a centre from whence are diverged thouſands of powerful and active atoms, which, when they meet our olfactory nerves, excite a ſmell, of whatever nature it may, pleaſant or fœtid, agreeable or offenſive. Theſe atoms, or particles, are received into the atmoſphere, where they float, and whereby they are diſtributed far and wide. Perhaps, I may illuſtrate the ſhare of the atmoſphere in this buſineſs, by referring you to a baſon of clear water, in which if you drop a little coloured liquor, the water ſoon becomes tinged, and the colour of the liquor ſpreads through the whole; attenuated, weakened, and thinned; which effect, no doubt, takes place on a larger ſcale in the atmoſphere with regard to odoriferous particles; and very much to our benefit, ſince we well know, that many ſmells are too ſtrong to be endured without inconvenience; that ſome are fatal though fragrant, becauſe *undiluted* (witneſs the

the pea-bloſſom,—damp, of mines) and that moſt are unhealthy if too conſtantly reſorted to. The tea-brokers in London (who judge of tea by ſmelling it ſtrongly) are greatly liable to the palſy; and the perpetual uſe of perfumes, among the women of Chili, produces an internal diſeaſe, as dreadful as incurable. But when a free circulation imbibes fragrance, or when fragrance is in its nature moderate, then it conduces to health and cheerfulneſs, refreſhes the ſpirits, and exhilarates the ſenſations; ſuch is the ſmell of morning and evening, ariſing from vegetation; ſuch is new mown hay; and many others, which are happily no ſtrangers nor rarities among us.

See from one ſimple covering ſurrounding our habitation, what various ſervices are beſtowed on the children of men; what various ſervices which come to our knowledge; but could we ſee the magazines of ſnow, the treaſures of hail, the repoſitories of froſt, the reſervoir of the drops of the dew; could we trace the ſprings and circulations of the electric fire, of the magnetic fluid (at which we can but gueſs); could we deſcend to the minutiæ of thoſe proceſſes conſtantly in motion, whereby vegetation is advanced, fertility increaſed, life prolonged by reſpiration, and many other beneficial effects produced, we might juſtly lay our fingers on our lips in adoring ſilence, and muſe that praiſe to which expreſſion is inadequate.

OBSERVATIONS ON THE PLATES

Belonging to LECTURE VIII.

PLATE I.

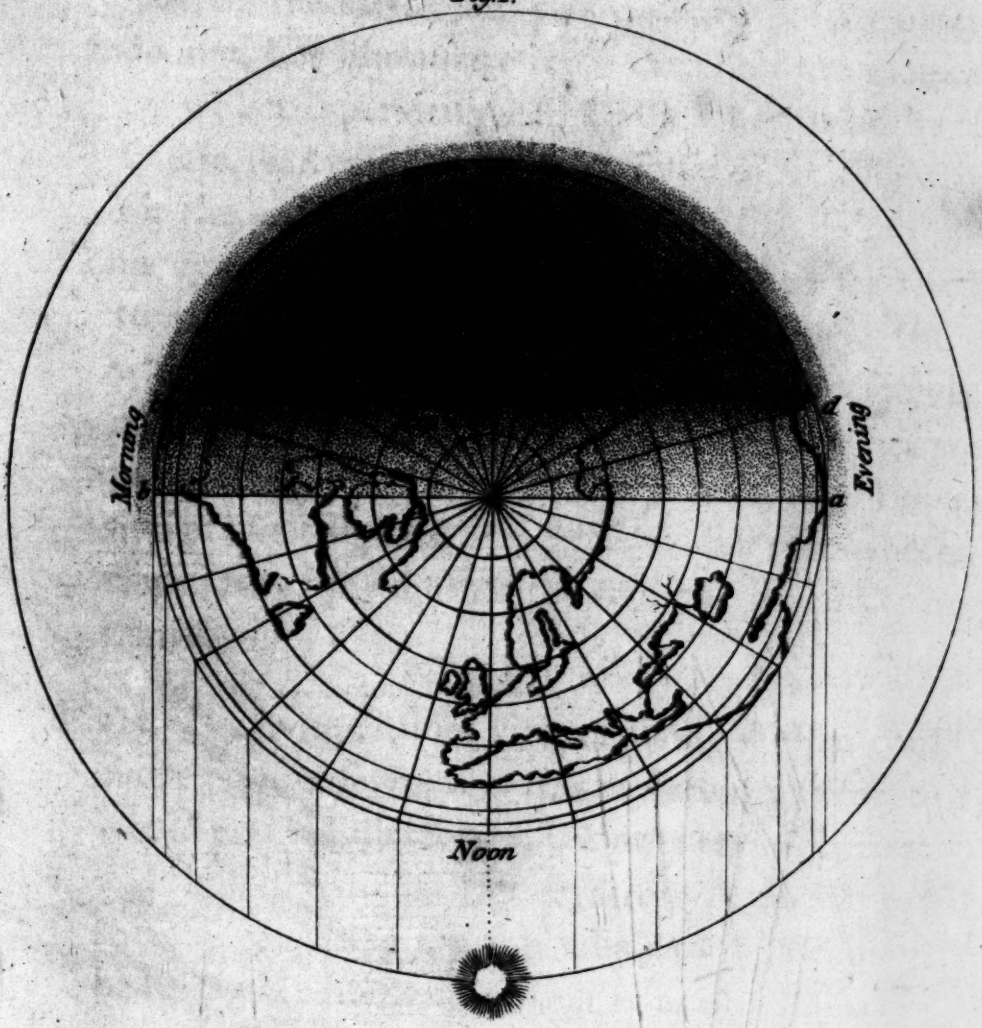
FIG. 1. repreſents a general idea of the benefits reſulting to the earth by the intervention of an ATMOSPHERE. This is ſuppoſed to be the northern hemiſphere; the north pole in the centre of the figure; the Sun in the equator, conſequently the *Equinox*.

It appears by the figure, that thoſe parts which have lately, by the diurnal rotation of the earth, turned from the ſun, and are loſing ſight of him (*i. e.* the part marked *Evening*), yet enjoy his beams by the refraction of the atmoſphere: were no ſuch medium around it, *a* would be involved in night; whereas, night is but juſt ſenſible at *d*, and the interval between thoſe letters, is gradually preparing for the total abſence of the ſolar luminary. At *Noon* the atmoſphere ſpreads the rays of light all around, and diffuſes equal and general brightneſs. In *Morning*, as the parts of the globe, *b* and *c*, turn toward the ſun, the light gradually advances, ſo that, although in ſtrictneſs only *b* ſhould be illuminated, yet the atmoſphere extends the ſolar rays to *c*, and prepares thoſe parts for perfect day. Thus it appears, that though the line *a b*, *ſhould be* the natural boundary of day and night, yet by this invaluable contrivance,

much

ATMOSPHERE and TWILIGHT.

Fig. 1.



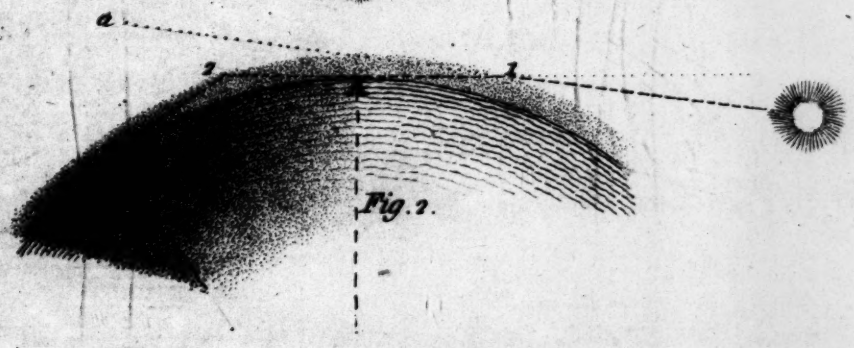


Fig. 2.

much beyond that line is reſcued from darkneſs, and *c d* is the actual boundary of light and ſhade. In fact, therefore, the very pole has now no night; though all other parts of the globe have equal day and night.

It is ſuppoſed in this figure, that the rays of the ſun fall *parallel* on the earth; but this we have already obſerved they do not, but illuminate more than half the globe *conſtantly*; by which ſuperiority, eſpecially when aided by the atmoſphere, darkneſs is very much leſſened, and light increaſed, for the purpoſes and enjoyments of life.

This figure is a kind of companion to that in the laſt Lecture, explaining the rotation of the earth: the circle in which the ſun is *ſuppoſed* to move, correſponds to that marked E Q, and the effect of the ſun, is what would take place when he is in the ſtation *f* 7. From the combination of theſe figures, ſeen in ſuch different aſpects, a very clear idea of the diurnal rotation and its effects may be attained.

Fig 2. Is a more diſtinct view of twilight than could be given above: we obſerve, that the ray from the ſun to 1, which would proceed direct to *a*, is by the atmoſphere at 1, caught and inflected to 2, juſt ſtriking A in its paſſage; and thereby rendering the ſun viſible to A, although that orb be below his horizon, which is 1, 2. This ray is again deflected from 2 to 3, where night begins; the ſun being full eighteen degrees below the horizon of any ſpectator ſuppoſed at 3. The ſpace from A to 3 is gradually darkened, till at 3 it becomes totally obſcure, and void of light.

PLATE

PLATE II.

FIG. 1. In this figure, the ATMOSPHERE is divided into ſeveral parts, according to the ſuppoſition hinted in the LECTURE. The groſſer diviſions next the earth, the lighter and thinner parts of the fluid further from it. If a ray from a heavenly body be ſuppoſed to proceed direct and ſtrait from the ſtar to the firſt diviſion, it is there a little inflected and bent downward; paſſing into the ſecond diviſion, it is ſomewhat more bent; in the third it is yet more attracted from its original courſe, till by the time it has reached A. it is conſiderably incurvated from its firſt direction; but as A ſees this ſtar by its light, and its light ſtrikes his eye in that direction which it has acquired in the groſſer medium, he will naturally ſuppoſe the object to be in that direction prolonged, and of courſe will eſtimate the ſtar at *a*, which, in fact, is below that ſtation.

If A be ſuppoſed inſpecting an object in the zenith Z; he will ſee it in its true place; becauſe, though the rays, as before, paſs out of a thinner medium into a groſſer, yet falling right upon every ſuch medium, their courſe continues to be direct and ſtrait forward, and ſuffers no refraction; but reaches A in the ſimpleſt manner poſſible, and alſo through the leaſt poſſible track of air, vapours, &c.

If A is imagined to be looking at the object *h*, which is in his natural horizon, he will ſee it through the greateſt poſſible quantity of vapours, and through the greateſt poſſible quantity of that part replete with the groſſeſt vapours; the diſtance from A to *h* being more than from A to *h*, and the comparative diſtance from A to the firſt line, very much longer on the line A *h*, than on the line A *h*; conſequently, here refraction is moſt powerful, and though never equal to that (employed to render it more evident

and

ATMOSPHERE.

Fig. 1.

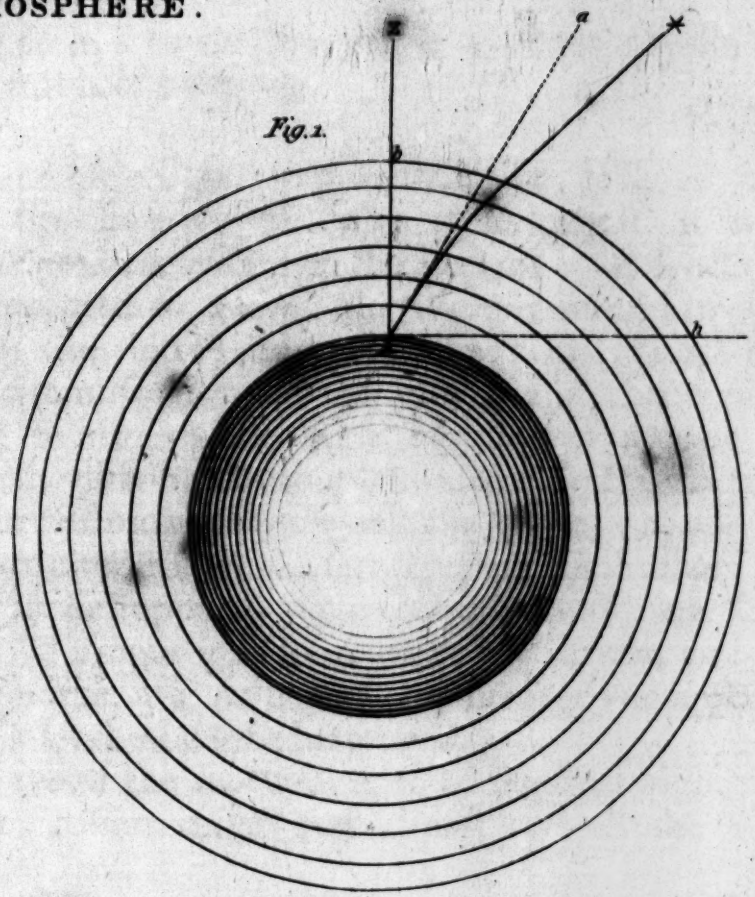
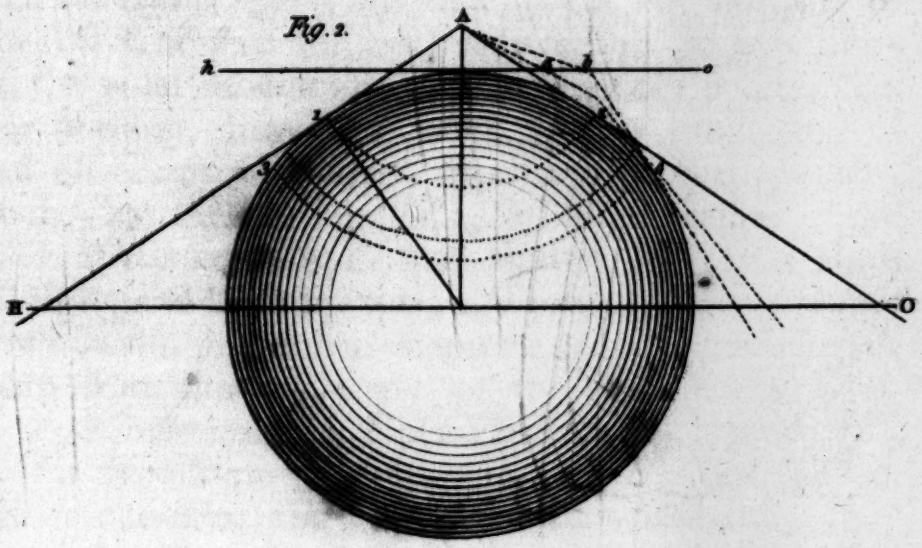
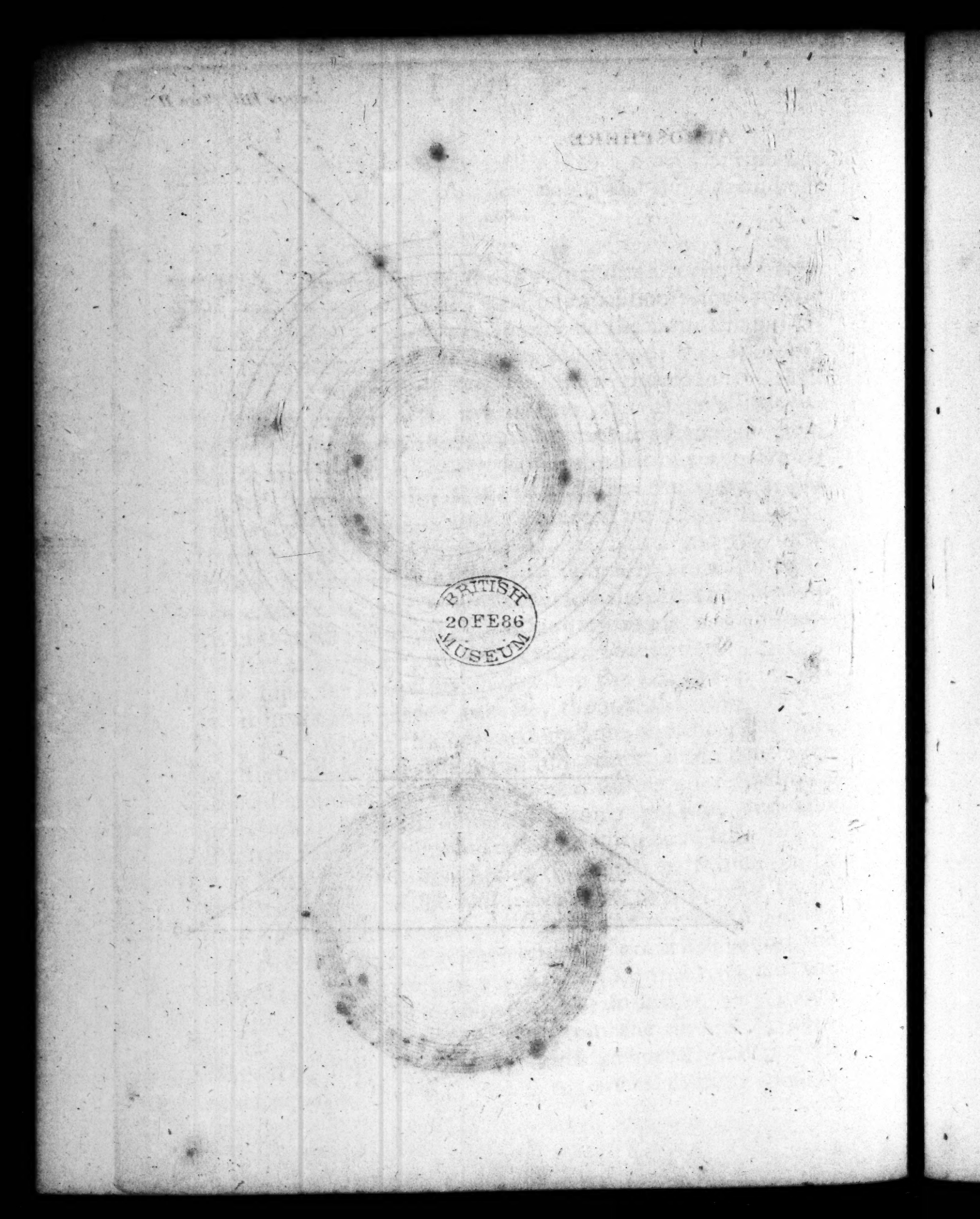


Fig. 2.





and distinct) from *a* to the star, yet it elevates objects on the horizon full half a degree.

Fig. 2. If refraction be augmented, or lessened according to the state of the air, it is certain it will produce correspondent effects on the horizon. A spectator A, may be supposed to survey the sweep around him 1 2 (expressed by the dotted line), for here his visual ray strikes the circumference of the globe, and this would appear level to him on the line *b o*: but if a body of aerial vapour be distributed around him, it refracts the rays coming to him from much beyond the circle 1 2, and he views a wider circumference; seen level on his horizon *ho* at *a*: if the air be supposed yet more replete with transparent vapours, it proportionably extends his survey, and he now sees the circle 3 4, which on his horizon *b o* appears extended on a level, and terminates at *b*.

Supposing the eye of the spectator A to be five feet high, the distance A 1 is four miles and almost two-thirds; *i. e.* 8125 yards.

No determinate distance can be assigned for the extent of the refracted horizon; unless the state of the air, and part of the world is known: for, as already hinted in the LECTURES, the polar inhabitants see the heavenly bodies, &c. on their horizon, through a much greater proportion of air, and also of gross vapours, than those at the equator: insomuch, that the sun regularly, at some seasons of the year, rises at the poles of an oval figure; his lower limb being heightened by refraction, and brought nearer to his upper, while his horizontal diameter remains unchanged. We learn from the testimony of the Hollanders, who, A. D. 1596, wintered in Nova-Zembla, in latitude 76°, that by the refraction of the atmosphere, they saw the sun *seventeen days* sooner, than by theoretic calculation, they ought to have done.

PLATE III.

FIG. 1. and 2. Refer to Mr. Hawkſbee's Experiment for aſcertaining the refractive powers of the ATMOSPHERE.

Fig. 1. The priſm is charged with an additional quantity of air, rendering its contents *double* what they would be in free air: in this compreſſed ſtate of the air in the priſm, the object appears at A; as the compreſſed air is let out, the object deſcends to its true ſtation in open air; *i. e.* from A to 1 and 2: which is a deſcent of ten feet and a quarter.

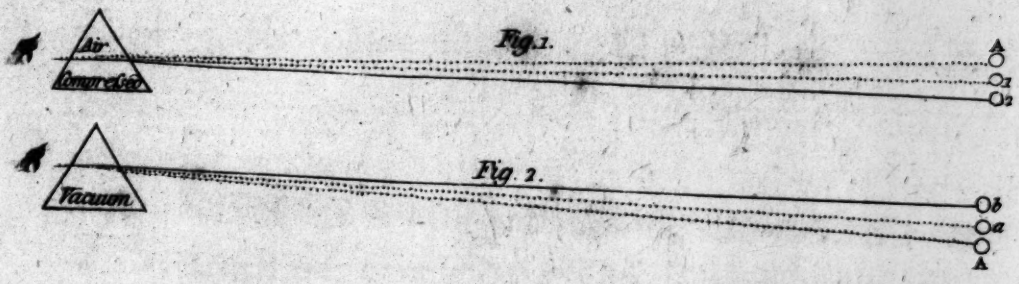
Fig. 2. The air contained in the priſm being gradually drawn away, the object deſcends from its true ſtation in open air *(b)* to *a* and A (ten feet and a quarter): upon the re-admiſſion of air into the *vacuum*, the object riſes from A, to *a* and *b*; merely by the refractive powers of the air ſo re-admitted.

SOUND. Fig. 3. This figure endeavours to repreſent the waves of agitated air, conveying ſound from the vibrating body A. At firſt they are ſtrong as 1, 2, 3, 4, but weaken as they recede from A to B; whoſe interpoſition prevents their progreſs, except at the orifice B, through which they proceed, as it were, afreſh, in *a*, *b*, *c*, *d*, *e*; weakening as they go, till they become inſenſible *(i. e.* the ſound becomes *inaudible)*. Thoſe rays which are ſtopped by the wall B, return, and form an ECHO, which weakens correſpondently to its diſtance from the reflecting body, as 1, 2, 3, 4, 5, 6, and at length becomes totally quieſcent.

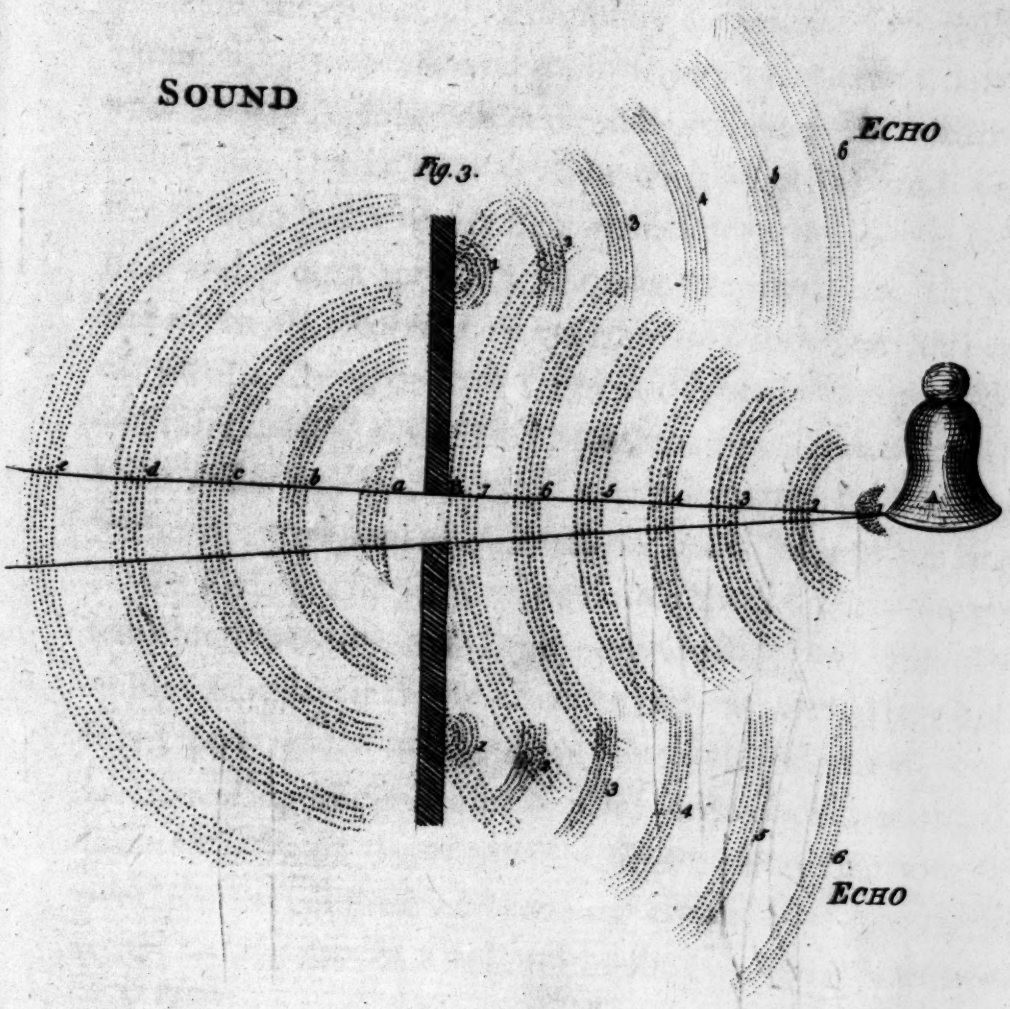
According to the ſituation of an auditor, he will hear the original ſound, and the echo more or leſs *ſeparate*; at echo 1, they will be almoſt union, but at echo 6, they will be diſtant.

LECTURE

ATMOSPHERE.



SOUND



LECTURE IX.

A MIXTURE of good and ill, characteriſes the preſent ſtate; our benefits are alloyed with attendant evils; and grateful alleviations accompany ſorrows. On this terreſtrial globe, life, pleaſure and delight, are brothers to death, anguiſh and miſery. Ever various, the mantle which ſurrounds our habitation! it is now replete with elegance and ſalubrity, is the ſplendid robe of royal magnificence: preſently, behold darkneſs and gloom terrific! flaming fire devours, thunder ſhakes the earth, the torrent pours its rapid force, or hail deſcends in dreadful volleys, or the whirlwind ſpreads ſweeping devaſtation.—Is the deluge paſt? The reverſe is equally fatal:—the Heaven with-holds its rain, no gentle dew deſcends, no cooling ſhowers; "the heavens above are iron, the earth beneath is braſs," "the cattle forſake the field where they drop their young; the huſbandman covers his head, deſponding for his tillage; the nobles ſend their little ones to the waters, they come to the pits; but return with empty veſſels, aſhamed, confounded, and covering their heads." Or, inſtead of health, the atmoſphere diffuſes mortality; flight is vain, the contagion overſpreads a country! remedy is vain, we breathe the peſtilence!—No longer a ſplendid robe; our mantle is now the en-

venomed garment which conſumes the vitals of the wearer. Happy Britain, which only by report conceives of theſe calamities, and only by ſympathy ſuffers theſe miſeries! To us ſuch deſolation is unknown:—yet we ſhould never forget that period when London was verdant with graſs, for want of paſſengers to tread the ſtreets.

But at this time, LADIES and GENTLEMEN, the atmoſphere which ſurrounds us is to be conſidered with regard to thoſe operations which are *conſtantly* carrying on in it, and which more immediately ſtrike our obſervation as belonging to the ſubject. Firſt, we treat of WINDS; and theſe we ſhall divide into CONSTANT, and INCONSTANT.

When I attribute conſtancy to the wind, I am aware that I ſeem to contradict daily experience; to this I reply, we muſt not ſo depend even on experience itſelf, as to exclude facts which oppoſe it: for though among us the vane is no emblem of ſteadineſs, till "it ruſt to a point, and fix at laſt," yet, in the proper latitudes of the Pacific ocean, the wind blows ſteady, in one uniform direction, and with one continued velocity; the ſeaman ſets his ſails, and almoſt forſakes the helm; night and day the breeze ſwells his canvaſs, and wafts his veſſel in full ſecurity; the wide-extended waters fear not tempeſt or ſtorm; never deformed by contending billows. Such is the deſcription of *ſome parts* of the great ſouth ſea.

There is ſomething ſtriking, to this purpoſe, in Commodore ANSON's voyage in the ſouth ſea. We read, at one part, of raging waves beating the ſcarce floating ſhip, raiſing her

her now mountain high, then plunging her deep into the abyſs, the veſſel pitching, toſſing, ſtruggling with the ſtorm; the wind quivering the maſts, and rending the ſails; cold, rain, ſnow, hail, in furious union combating the adventurous navigator, whoſe frozen limbs almoſt forego their life. Afterwards, we read of weather which permitted every ſail abroad, and wafted them ſafely acroſs the immenſe Pacific.—In fact, veſſels going with the breeze, uſually make their paſſage in ſix or ſeven weeks, while others going the contrary way, are obliged to avoid the limits of the trade-wind, and employ not leſs than ſix or ſeven months. Such is our account of Conſtant Winds, which alſo blow in the Atlantic and Ethiopic oceans with equal permanency.

There are alſo Winds of *contradictory* Conſtancy: I mean, which one part of the year blow with ſettled regularity in one direction, the other part of the year they blow with equal ſteadineſs from an oppoſite point. Theſe are termed *Monſoons*, from a pilot of that name, who firſt adapted them to the purpoſes of his navigation.—The interval between the changes of the Monſoons is the ſeaſon of tempeſt, and is termed the *breaking up of the Monſoons*.—Theſe winds have their ſtations, and are bounded often by a projection of land, as peninſular India, on one ſide of which the coaſts are haraſſed with hurricanes, on the other they never know them.

As theſe winds occupy the moſt conſiderable part of the globe, we ſhall here endeavour to explain their cauſes.

Of the trade-wind we obſerve, that it reigns, where reigns the greateſt ſolar heat, *i. e.* at, and adjacent to, the Equator;

we have already noted the ardour of the ſun in theſe parts, and it ſhould ſeem, that his fiery beams by rarifying the air, and by heating the earth, cauſe a perpetual vacuity in the adjacent atmoſphere; to ſupply this vacuity, the air from all quarters ruſhes with proportionate velocity. If you pleaſe, we will examine this matter ſomewhat more cloſely: for a moment we ſuppoſe ourſelves beneath the line; at noon the ſun is vertical, and darts his perpendicular rays with intenſe fervor; the air around us feels this fervor, and expands on all ſides, it widens, it ſpreads, it recedes from this ſcarce-ſuſtainable heat;—thus equally expanded it will continue while the ſun is high; but when he declines, the expanſion declines alſo in that quarter which he forſakes (*i. e.* the Eaſt), and thereby, ſuch quantity of atmoſphere as lately occupied very conſiderable ſpace, is now contracted into ſmaller dimenſions, and leaves a void—which void is regularly ſupplied from whereever the air can ſupply it. As the daily progreſs of the ſun is from eaſt to weſt, this ſupply of air will follow the ſolar progreſs; *i. e.* will blow from the eaſt; and, I apprehend, were no impediment interpoſed, this eaſt wind thus following the ſun, would be violent: but we muſt regard, as one bar to its violence, that heat which remains in the earth after the ſun has quitted it; for the earth being a denſe body, retains heat in great quantity, and this it continues to emit, in proportion as the atmoſphere ſhews any diſpoſition to refrigeration. Thus it appears theſe parts of the atmoſphere are conſtantly heated—exceſſive hot at noon, little leſs in the evening, and at night are far from temperate.

I might

I might add, as another cauſe of this eaſt wind, that the ſolar progreſs, is *preceded* by an expanſion of air: I ſay, the motion of the ſpreading atmoſphere *precedes* the ſun, and conſequently puſhes *forward* and impels the body of air toward which it is *advancing*; this not only prevents any wind from this quarter toward the eaſt, but alſo, what with this impulſe on a quantity of air to make room for that which is now expanded, or expanding, and that attraction we have already noticed of air to ſupply the evening vacuum, I think we may ſee the reaſons why this wind blows night and day from the ſame quarter; *i. e.* it is *puſhed forward* before the ſun, and *drawn* after him, over by much the greater part of the globe; and in thoſe other parts, where the ſolar rays do not reach either directly or by refraction, the night is not cool enough to permit any ſettling of the atmoſphere, before the ſun proceeds to renew his impulſe. We may add, that the time of greateſt daily heat, which is doubtleſs that of greateſt expanſion, is after the ſun has paſſed the meridian of any place; conſequently, the heat left by him continues its attraction of air from thoſe parts he has quitted; for where he is now vertical none can be ſpared.

Recollect, if you pleaſe, that on each ſide the equator the ſun has leſs ſtrength; that in the high northern and ſouthern latitudes his influence is nothing, compared to what we have deſcribed, and it is eaſy to conceive that breezes from theſe cooler regions ſupply the daily demand of the aerial fluid in the torrid zone. Theſe partake of two directions; firſt, their own natural courſe, the neareſt and moſt direct to where they

are

are wanted; and, ſecondly, That of the ſtream of air in which they are gradually intermixed: thus, from the north, the combined courſe will be a mixture of north and eaſt; from the ſouth, of ſouth and eaſt; and to this agrees obſervation: for we find, that on each ſide the equator, to about 27 or 30 degrees, the wind does more and more decline from the eaſt to the north eaſt, on one ſide, and to the ſouth eaſt on the other. The heated air moſt probably paſſes in a counter-current *over* thoſe currents of air we have noticed; in high latitudes, therefore, where theſe counter-currents predominate, they not only check the former gradually, but themſelves become ſenſible by blowing in oppoſite directions.

If the ſun is chief operator in theſe permanent winds, we may, without heſitation, admit his influence in thoſe which are PERIODICAL. The Monſoons owe their origin to the annual courſe of the ſun, which is, you know, LADIES and GENTLEMEN, one half of the year north of the equator, the other half ſouth of it. While he paſſes through the northern ſigns of the ecliptic, his verticality moves into countries not before equally expoſed to his beams; Arabia, Perſia, India, China, are now heated; while the ſouthern parts, becoming cool by the abſence of the ſun, may detach ſome of their cooler atmoſphere to where the ardour of that celeſtial luminary is exceſſive. Conſequently, in certain places, approaching to where the ſun is vertical, the current of air will now partake of the motion imparted to it by this greater proportion of breezes from the ſouth. In return, when the ſun croſſes the line, and reviſits

reviſits the South, the northern breezes will prevail, and the monſoon will change.

Such are the general cauſes of theſe periodical winds: but that many winds may juſtly be denominated LOCAL, is paſt a doubt: and it is likely that many local cauſes may influence the courſes of the monſoons themſelves, as well in ſtrength as in direction. We obſerve, that however ſteady be the wind which blows over the ſurface of the ſea, yet on our approach to land, its ſteadineſs forſakes it: even in the very midſt of the permanent trade-wind, the coaſts of Africa and America often contradict, and always divert its progreſs. The cauſe of this is ſimilar to principles already introduced; the heat imbibed by theſe countries, with their elevations and projections, combine to arreſt, in ſome degree, the trade-wind, and to attract it out of its courſe; and here we muſt regard as well the nature of the ſoil, as the courſes of rivers, and the luxuriance of vegetation.

Africa has many and wide-ſpread deſerts, where the ſandy plain is little broken by declivities, or variegated by plantations. Here, therefore, the ſolar rays are rebounded with great vehemence, and occaſion correſpondent effects on the atmoſphere. We conceive little of theſe effects by adverting to the reflection of a gravel walk in our own country; yet even among our gardens, we are ſenſible the heat ariſing from ſuch an object exceeds that from a verdant lawn: what, then, is the ardour of an African deſart, on all ſides ſand, beneath a vertical ſun! for this reaſon, the wind round about the coaſt of Guinea blows conſtantly to land, the air upon the

waters near the ſhore being leſs heated than that of the country: which probably riſes high into the atmoſphere, and in its turn reviſits cooler regions.

The limits or junctions of theſe winds is a ſtate of contradiction: CALMS and TORNADOS! I mean, that for many degrees beneath the equinoctial line, the extremes of theſe winds meet each other: when they equiponderate, all is huſh, not a breeze moves the ſmooth pool: but when any one attempts to ſurpaſs the others, it excites the heavens to raging ſtorms, the winds blow dreadful from all quarters, and whirl the rolling waves in reſtleſs eddies. Unhappy the veſſel which here attempts a paſſage! the dead calm is fatal! fatal is the direful ſtorm! What gentle gale ſhall waft the impriſoned ſailor from this ſcene of alternate calamity!

The winds we have mentioned continue for ſome time. There are others more uſually denominated BREEZES, which viſit many of the countries in warm climates, blowing part of the day from the ſea, the other part from the ſhore. The ſea-breeze, as DAMPIER obſerves, commonly riſes in the morning, proceeding ſlowly in a fine, ſmall, black curl upon the ſurface of the water, and making its way to refreſh the ſhore: it is gentle at firſt, but gradually increaſes till noon, then equally gradually declines, and ere evening is totally huſhed: after a little ceſſation, the land-breezes take their turn, and having gradually enjoyed their increaſe, they as gradually decay. How far theſe may be denominated aerial tides, I cannot determine; ſince, if ſuch they are, and dependant on the daily rotation of the ſun, many cauſes may perplex ſo

light

light a fluid as air, and deprive it of that calculation to which water ſubmits. The leſs dubious method of accounting for them is on principles already adduced, *i. e.* of expanſion and contraction of the heated atmoſphere; not that this explains every principle, ſince in ſome places the time of theſe breezes is contrary to what other places experience: they riſing in the morning to ſome, at night to others.

I will not decline the gratification of remarking, how kindly Providence has attended to the wants of its creatures, in this alternate refreſhment attendant on the changing breezes. On moſt of theſe coaſts the heat would be inſupportable, did not this air from the ocean moderate its intolerance. On the other hand, the land-breeze corrects the malignity of the dews, of the marine and other vapours, and renders wholeſome what otherwiſe were noxious. Theſe breezes, it appears, therefore, beſtow a ſhare of health and enjoyment, which the ſame latitudes, where they do not obtain, or further in land, may regard with envy.

Thus far has human ſcience ventured to ſuggeſt the leading cauſes of atmoſpheric currents: not ſcience, but raſhneſs, preſumes to account for every occurrence which challenges notice. Science knows too well how much is hidden, totally hidden; and, conſcious of deſerving applauſe for what it has developed, it leaves boaſting to thoſe whoſe pretenſions are their diſtinctions. The obſervation is yet juſt, that we hear the ſound of the wind as it paſſes by us, but we cannot determine the cauſe of its motion; can neither tell its origin, nor its ceſſation.

There

There are many cauſes which expand or compreſs the air: clouds will do this; and thus the ſailors often ſay (juſtly) in ſultry days, "Every cloud carries its own wind." The morning has its wind; at noon, perhaps all is calm; as the ſun declines, the cool of the evening has its wind. Mountains and hills, if they do not produce wind, yet divert its progreſs, and produce it where it would not otherwiſe be: currents of water occaſion correſpondent currents of air; and this was diſtinctly obſerved in certain of the balloon excurſions, where ſome danger attended croſſing of rivers near their diſcharge into the ſea, leſt their attendant ſtreams of air ſhould counteract that which carried the machine. Nay, I have been told, that one of Blanchard's excurſions was little other than a paſſing and repaſſing, in almoſt contrary directions, for ſeveral miles, as carried by an aerial current aloft, winding with a river; while the wind in the ſtation he quitted continued the ſame.

The wind upon land is ſeldom ſo ſteady as at ſea, but blows more uncertainly; which probably is owing to the reſiſtance of mountains, hills, valleys, &c.; or even buildings and trees may affect it; for it is not to be thought, that the current of air which glides over the ground is always of ſuch a height, as that buildings ſhould bear no proportion to it; on the contrary, though the wind may be pretty ſtrong, we often ſee clouds, apparently moderately high, advancing contrary to it; and, indeed, I doubt not that clouds are uſually at different heights; and when they move contrary ways, each with its wind, yet there may be conſiderable intervals of calm (or balance of winds) between them.

The extent of winds which are not permanent, is difficult to determine: if we may judge by the progreſs of thoſe ſtorms whoſe effects have rendered them remarkable, they extend to conſiderable diſtances. The effects of a ſtorm, which ſhould ſeem to have originated over the Atlantic ocean (Oct. 1781), were felt at Barbadoes, as coming from the north-weſt; at London a branch of the ſame ſtorm was felt, coming from the ſouthward; it croſſed England, and was ſuppoſed to have viſited as far north as Sweden. This ſpace, as near as I can recollect, it traverſed in about three days. We cannot, by theſe kind of inſtances, determine the velocity of wind, or the rate at which it travels, ſince, beſide the ſuppoſable fury which might animate ſuch a ſtorm, it is obvious to remark, that its outſet was probably much ſwifter than after it had reached any conſiderable diſtance. The uſual going of the wind, may be, I ſhould think, pretty well judged of by navigators, who uſually calculate it at about four or five miles per hour. In ſtorms, it ſometimes blows at the rate of fifteen or twenty miles; and in very great ſtorms, it has been computed at little leſs than fifty, or even ſixty miles.

A perſon on horſeback may eaſily outride the general courſe of the wind; but if its ſwiftneſs may be computed from the progreſs of that ſmall cloud which indicates hurricanes, it is very great; as this cloud is often little more than an hour in advancing from the edge of the apparent horizon to the zenith. So expreſſive is that idea of the Pſalmiſt, "He (God) *walketh* on the *wings of the wind.*"

The tranſition is not great, from winds to CLOUDS and VAPOURS,

VAPOURS, their uſual companions; to which we ſhall now direct our remarks. The atmoſphere I conceive to be a vaſt laboratory, in which are performing all manner of chemical proceſſes; the leading principle of theſe proceſſes I apprehend is *equality* or *balance*. Is any thing too hot, the ſurrounding air cools it: is any thing too cold, the ſurrounding air heats it: according to its own temperature, depriving whatever is expoſed to it, of either heat or cold. Is any thing too wet, the air dries it: or if too dry, the air will moiſten it. Thus it ſeems, that wherever it finds redundance, the air leſſens the ſuperfluity; and wherever it diſcovers poverty, it depoſits ſome addition of what is wanting. The ſuggeſtion of this general good derived from the atmoſphere, opens the mind to many uſeful leſſons; it is a leading idea, which branches out into a thouſand beneficial remarks: for be it remembered, theſe qualities are infinitely advantageous to the inhabitants of this fluid, are conſtantly exerciſing without our influence or direction, and ſhould they ceaſe, though but for a little time, miſery and deſolation would enſue. How many proofs of this aſſertion are daily happening in places ſhut up from a free circulation of air! Cells and dungeons, mines and caverns, even manufactories and dwellings, where this ſalubrious viſitant is denied acceſs, or where its influence is impeded or reſtrained, are ſo many inſtances of the neceſſity for thoſe active qualities which Supreme Wiſdom has beſtowed on the atmoſphere.

CLOUDS are miſts and vapours elevated in the atmoſphere, of the ſame nature with thoſe which often obſcure the ſurface

of

of the earth. As theſe lower examples are more familiar to examination, they may ſerve as ſpecimens of clouds in general. There is no one of my auditory who has not been enveloped in a fog; which fog originated, moſt probably, from ſome low and marſhy ſituation, or from ſome river whoſe courſe ran through ſuch a ſituation. This fog then, contained a watery vapour, impregnated with effluvia—from the earth long ſoaked in water,—from plants growing in ſuch marſh, and—from every body or thing capable of emitting vapour, even ſtones themſelves: it follows, that from ſuch combination may be expected the almoſt ſolid ſteam of a ſtinking fog. This may be varied, or diminiſhed, according to the ſoil and other circumſtances. It is very rare that any appearance, deſerving the name of a fog, originates, or maintains itſelf upon hills, where the deſcent carries off the water rapidly. Here we find MISTS, *i. e.* vapours, ariſing from the earth and its plants, &c.: theſe, viewed at a ſmall diſtance, even while on the very ſurface of the ground, aſſume the appearance of clouds; and when ſomewhat elevated, are not to be diſtinguiſhed from their brethren of longer duration. To this agrees a remark of one of the balloon voyagers, "that certain clouds ſeemed to be only miſts; and while he was paſſing through them, ſeemed to *recede* from him, and become inſenſible, aſſuming an appearance as if they were *opened* for half a mile on each ſide of him," *i. e.* they were ſo thin as to elude his ſight, except when ſeen in a conſiderable body.

I am very well aware, that much ingenuity, in various forms, has been employed to account for the riſe of vapours: ſome

have ſaid, that all water has a quantity of air mixed with it; and this air being rarefied by heat, carries with it particles of water. The idea that air diſſolves and unites with water, and by ſuch union the water is raiſed with the air, has been ſuggeſted by Dr. HAMILTON, and lately ably ſupported by Dr. WATSON, biſhop of Llandaff. It is urged, that as a lump of ſugar is diſſolved in a cup of tea, without injuring its tranſparency, and without our being able, in the ſmalleſt degree, to diſcover what is become of the ſugar; or as ſalts are diſſolved in water, forming a complete union with it,—ſo water is diſſolved in air, and the air thereby loſes nothing of its diaphaneous property; nor is it changed, except by becoming more refractive than before. Again, as warm water will more readily and more amply diſſolve ſalts, and, upon cooling, will depoſit thoſe ſalts, which, though it held while warm, it cannot hold when cool,—ſo, in the morning, vapours are viſible in the atmoſphere; but noon being warmer, thoſe vapours are more completely diſſolved, and the air becomes tranſparent: as it cools toward evening, they again make their appearance. More than this, if we take a bottle of wine, for inſtance, out of a cool cellar, and place it in warm air, the coldneſs of the bottle will chill the air immediately adjacent to it; the air, thus chilled, becomes unable to ſuſtain the vapour it did while warm, and will depoſit it on the ſurface of the bottle. That the air abounds with an acid we know; and we know alſo ſome of its effects, ſuch as ruſting, (corroding) iron, tarniſhing ſilver and braſs, and forming upon copper veſſels that highly dangerous article verdigris. No doubt it *may* corrode

water

water alſo. But of late it has been ſaid, that water is only a reſult of the union of different kinds of air: by affinity, therefore, air may imbibe water. After all, I cannot refrain from adding that principle of equality, which, I think, ſeems to be very intimately connected with, and to be one great duty of the atmoſphere: a dry froſt evaporates as much water as a hot day, becauſe the air is void of moiſture; a hazy day evaporates little water, becauſe the air is ſufficiently impregnated. When the wind is briſk, water evaporates briſkly, becauſe expoſed to the action of a greater number of aerial particles which *want water*. Even when the ſun is totally concealed, and when cold has congealed the waters, evaporation yet proceeds: nay, after the glebe has been almoſt turned to ſtone by froſt, or is parched into fiſſures by heat, ſtill it yields copious vapours and ſteams. In fact, the air is replete with water. It has been calculated, that were it totally extracted and condenſed, it would be ſufficient to cover the ſurface of the earth to a depth of thirty feet: and this quantity is kept ſuſpended in the atmoſphere, without our being in any degree ſenſible of it, either by ſeeing or feeling it.

Vapours raiſed into the air are clouds; clouds collected together and forming one maſs, are by ſuch union compreſſed into a ſmaller compaſs; this compreſſure forces the particles of theſe ſmall vapours into a junction with each other, thereby forming drops; which drops coaleſcing, are enlarged, till, unable to float any longer in the air, they deſcend in RAIN. The water burſts in a torrent; but the height from which it falls, and the reſiſtance it meets from the air in falling, divides

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the torrent into ſtreams, the ſtreams into rills, the rills into rain, which is more or leſs drizzling and gentle, or bulky and heavy, according to the ſize and height of the cloud, to the ſtate of the air, and the force of the wind; whether it drives the clouds ſuddenly and tumultuouſly together with rapid ſhocks, or gently approximates them to each other.

Not unlike this is the hiſtory of DEWS; vapours exhaled by the ſun's warmth, but not elevated ſo high as to form clouds: theſe, when the atmoſphere is cooled by the ſun's departure, deſcend as gently, if not ſo imperceptibly, as they aroſe. Dews partake ſo ſtrongly of the quality of the ground from whence they are exhaled, that no two chemiſts find the ſame reſult in ſuch quantities as they examine ſtrictly: the dews from ſome places being clear, limpid, and inſipid; while other dews are ſo ſtrong and ſpirituous, as to burſt the veſſels wherein they are examined, and to ſtain the glaſſes of various, and ſometimes highly beautiful colours. If dews are thus various, no doubt clouds are the ſame; and here we ſee one beneficial office of the winds, which impel theſe vapours, pregnant with certain principles (abundant where they were raiſed), to other parts, where ſuch principles are not in equal plenty; and, return with other clouds, importing other principles, thereby diffuſing fertility all around. Dews may be divided into, (*1ſt*,) the evening, and (*2d*,) the morning dew. Of the firſt we have ſpoken: the ſecond ſhould ſeem to be compoſed of ſuch vapours as had riſen during the day into a higher ſtation than the former, where they remained ſuſpended during the calm of night: the approach of the ſun begin-

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ning to warm the air, though very gently, dilates the atmoſphere; this emotion becomes a breeze, ſometimes mild, ſometimes cold. The rarefied vapours, hereby impelled toward each other, coaleſce, condenſe, and deſcend in dew: ſo that this (the morning) dew, partakes yet more of the nature of rain than the evening dew, though it never formed clouds, or became ſenſible in the atmoſphere. I need not remark its utility: the earth imbibes it greedily, and vegetables rejoice at receiving falling dew, their moſt wholeſome, and probably their moſt delicious nutriment.

HOAR FROST ſhould ſeem to be frozen dew; I mean, thoſe vapours which in warm weather would deſcend in gentle dew, are in cold weather ſo condenſed, as to become a kind of white cruſt, on the ſurface of whatever body they cover. Such is the *frozen* "dew-drop trembling on the ſpray."

VAPOURS which riſe higher into the region of clouds, are ſubject to greater effects of cold; when what ſhould be rain is frozen quickly after it leaves its parent cloud, very large HAIL enſues, and much damage may be expected: if frozen lower down, it is generally little more than rainy congelation, ſmall, ſoft, and ſoon melted.

SNOW is vapour frozen while high in the air; whoſe parts uniting in its deſcent, form the flake of ſnow, how large ſoever it be when it reaches the earth. Theſe ſmaller parts are always of a regular form, ſhooting out ſix little points, whoſe extreme thinneſs occaſions them to melt when received into the hand; but if they were ſufficiently ſtrong to be permanent, they would wound like ſo many prickles. We are

under many obligations to ſnow, as it defends our plants from the cutting ſeverity of winds and froſts; but it does not contain more nouriſhment than rain, nor any nitrous or other principle, whereby it may juſtify the opinion formerly held of its nutritious effects. Capt. JAMES, in his Voyage toward the North Pole, mentions, that the vapours which aroſe from the lower part of their hut, were condenſed by the ſevere cold in the upper part of the ſame hut, and deſcended in the form of ſnow. How great was that degree of cold, to produce this effect, notwithſtanding the ſtrongeſt fire they could raiſe!

LIGHTNING and THUNDER have their ſeat in the atmoſphere: the latter ſhould ſeem to be merely the echo, reverberated among the clouds, of the exploſion cauſed by the former; and is more or leſs violent and frequent, according to circumſtances. I confeſs it is a very awful and majeſtic ſound, but is in itſelf no cauſe for alarm: and as to the ſtory of a thunderbolt, it has no foundation in nature. The danger attends the lightning; and this is among the ſubjects whoſe cauſes we may underſtand in general, without being able to account for many particulars. We know that Electricity has imitated moſt of the phenomena of lightning, and that the electric fluid abounds every where, and in every thing; that ſome bodies are capable of containing much more of this fluid than others; that when ſuperſaturated with it, they diſcharge it to others which are deficient in the quantity they are capable of receiving: if, therefore, a cloud, or a part of the atmoſphere, be *over-charged*, while another is *under-charged*, the latter will attract from the former. That ſome vapours exhaled

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from the earth ſhould abound more than others with this fluid, is not ſtrange; that theſe ſhould be eſpecially exhaled by the ſtronger action of the ſun, is very conceivable; and that they ſhould be held buoyant for a time, and only diſcover themſelves by their effects, may be readily granted.

Should any aſk, what is the electric fluid? I can only anſwer, that I ſuppoſe it to be, if not that elementary fire which is appointed to our globe, yet one modification and appearance of it. Its abounding in nitrous and ſulphureous vapours, (which yield moſt of what is gueſſed to be the matter or principle of heat, termed *phlogiſton*) ſeems to ſupport this ſentiment: and I apprehend, that to this cauſe we may refer the *Aurora Borealis* in its various forms, and probably many other atmoſpherical particularities; nor is it ſuppoſed to be without its influence in many operations to which even the ſolid earth is liable.

Theſe ſubjects, we are certain, belong to the atmoſphere; but there is yet a phænomenon, which has cauſed much debate, whether its origin belong to the atmoſphere, or to the ſea; I mean a WATER-SPOUT. The deſcriptions given us of thoſe objects by ſuch as have ſeen them, inform us of much that is curious, but little that is demonſtrative.

Thoſe ſeen by Tournefort, in the Mediterranean, he has deſcribed as follows: "The firſt we ſaw, was about a muſket-ſhot from our ſhip. There we perceived the water began to boil, and to riſe about a foot above its level. The water was agitated and whitiſh; and above its ſurface there ſeemed to ſtand a ſmoke, ſuch as might be imagined to come from wet

ſtraw before it begins to blaze. It made a ſort of a murmuring ſound, like that of a torrent heard at a diſtance, mixed, at the ſame time, with an hiſſing noiſe, like that of a ſerpent: ſhortly after, we perceived a column of this ſmoke riſe up to the clouds, at the ſame time whirling about with great rapidity. It appeared to be about as thick as one's finger; and the former ſound ſtill continued. When this diſappeared, after laſting for about eight minutes, upon turning to the oppoſite quarter of the ſky, we perceived another, which began in the manner of the former; preſently after, a third appeared in the weſt; and inſtantly beſide it ſtill another aroſe. The moſt diſtant of theſe three could not be above a muſket-ſhot from the ſhip. They all continued like ſo many heaps of wet ſtraw ſet on fire, that continued to ſmoke, and to make the ſame noiſe as before. We ſoon after perceived each, with its reſpective canal, mounting up in the clouds, and ſpreading where it touched; the cloud, like the mouth of a trumpet, making a figure, to expreſs it intelligibly, as if the tail of an animal were pulled at one end by a weight. Theſe canals were of a whitiſh colour, and ſo tinged, as I ſuppoſe, by the water which was contained in them; for, previous to this, they were apparently empty, and of the colour of tranſparent glaſs. Theſe canals were not ſtraight, but bent in ſome parts, and far from being perpendicular, but riſing in their clouds with a very inclined aſcent. But, what is very particular, the cloud to which one of them was pointed happening to be driven by the wind, the ſpout ſtill continued to follow its motion, without being broken; and paſſing behind one of the others, the

ſpouts

ſpouts croſſed each other, in the form of a St. Andrew's croſs. In the beginning they were all about as thick as one's finger, except at the top, where they were broader, and two of them diſappeared; but ſhortly after, the laſt of the three increaſed conſiderably; and its canal, which was at firſt ſo ſmall, ſoon became as thick as a man's arm, then as his leg, and at laſt thicker than his whole body. We ſaw diſtinctly, through this tranſparent body, the water, which roſe up with a kind of ſpiral motion; and it ſometimes diminiſhed a little of its thickneſs, and again reſumed the ſame; ſometimes widening at top, and ſometimes at bottom; exactly reſembling a gut filled with water, preſſed with the fingers, to make the fluid riſe or fall; and I am well convinced, that this alteration in the ſpout was cauſed by the wind which preſſed the cloud, and impelled it to give up its contents. After ſome time, its bulk was ſo diminiſhed as to be no thicker than a man's arm again; and thus ſwelling and diminiſhing, it at laſt became very ſmall. In the end, I obſerved the ſea, which was raiſed about it, to reſume its level by degrees, and the end of the canal that touched it to become as ſmall as if it had been tied round with a cord; and this continued till the light, ſtriking through the cloud, took away the view. I ſtill, however, continued to look, expecting that its parts would join again, as I had before ſeen in one of the others, in which the ſpout was more than once broken, and yet again came together; but I was diſappointed, for the ſpout appeared no more."

Dr. STUART's deſcription (Philoſophical Tranſactions, No. 277.)

277.) agrees well enough with the foregoing; but he obſerves, the clouds were black, lowering, heavy with rain: the ſpouts were black alſo,—ſmooth,—ſome perpendicular,—ſome oblique, at times increaſing and diminiſhing;—and the water ſeemed affected *before* the cloud. It is debated, whether this be a riſe of water into the cloud, or a deſcent of water from the cloud. Dr. STUART conſiders it as a riſe of water from the ſea into the cloud, and hints at ſuction as the cauſe of this aſcent, thinking the affair is elucidated by the effect of a cupping-glaſs on the ſkin: others have ſaid, a vacuum is the cauſe; and the preſſure of the air being taken off, the water will riſe; others think, a whirlwind muſt be added. Perhaps ſeveral cauſes combine; but it is ſo rare that any naturaliſt is favoured with theſe ſights, that every theory is liable to ſuſpicion.

We have an account of a (probably) ſimilar kind of ſpout ſeen upon land, which the ſpectator acquaints us, he thought, had it been at ſea, would have been a water-ſpout, *i. e.* would have attracted and imbibed the water over which it might have paſſed.

"The ſeaſon in which it appeared was very dry, the weather extremely hot, and the air very cloudy. After the wind had blown for ſome time with conſiderable force, and condenſed the black clouds one upon another, a great whirling of the air enſued; upon which the centre of the clouds every now and then darted down, in the ſhape of a thick, long, black pipe; in which the relator could diſtinctly view a motion, like that of a ſcrew, continually ſcrewing up to itſelf, as it were, what-

ever it happened to touch. In its progreſs, it moved ſlowly over a grove of young trees, which it violently beht, in a circular motion. Going forward to a barn, it in a minute ſtript it of all the thatch, and filled the whole air with the ſame. As it came near the relator, he perceived that its blackneſs proceeded from a gyration of the clouds, by contrary winds, meeting in a point or a centre; and where the greateſt force was exerted, there darting down, like an Archimedes's ſcrew, to ſuck up all that came in its way. Another which he ſaw, ſome time after, was attended with ſtill more terrible effects; levelling, or tearing up great oak trees, catching up the birds in its vortex, and daſhing them againſt the ground. In this manner it proceeded, with an audible whirling noiſe, like that of a mill; and at length diſſolved, after having done much miſchief." *Philoſophical Tranſactions*, No. 281.

I was lately converſing with the Rev. Dr. D. on this ſubject, who aſſured me, he had more than once ſeen nearly the ſame occurrence: he remarked alſo, that this whirlwind or gyration, in croſſing a ſmall river, beat about the water at a ſtrange rate, driving it forwards over its bank in a ſtrong foam; but, probably, there was neither ſufficient water, nor ſpace, to permit a water-ſpout.

It is well for mankind, that the benefits attending the operations of nature, are neither confined like our knowledge, nor variable with our opinion: but, be our ſentiments of them what they may, we are not the leſs beholden to their conſtant advantages.

The immediate advantages of a water-ſpout, indeed, do not

appear;

but we muſt own, it is happy for us they are more frequent at ſea than on land; for what havock might ſuch a phænomenon make, if its fury were exerted on our metropolis! But if any are willing to remove alſo thunder and lightning, hail and ſnow, it can be only becauſe they know not what important ſervices they render us. Thunder and lightning clear the air from inſects, and deſtroy what might be the ſeeds of peſtilence; often are they deſired by the gardeners. Cold and congelation purify the air, and render it more capable of performing its ſhare in the functions of life: in a vaporated, heated, relaxed medium, we rather exiſt than live.

In fact, unlimited Wiſdom has endowed the atmoſphere with many powers for remedying thoſe diſorders to which it is liable; where it is ſtrongly impregnated with vapours during the day, they are diſmiſſed in rains at night; if impregnated with ſulphureous vapours, they are diſſipated in lightnings; but if replete with pure electric fluid, it becomes luminous, and enlivens the dreary north with light and ſplendour.

We begin to perceive, by theſe hints, of what immenſe uſe is the atmoſphere; but obſerve alſo, how it receives the vapours of the earth, of plants, of animals, of waters, of putreſcent ſubſtances of every kind: theſe, ſeparately, are in themſelves highly noxious; but united, they correct each other, are purified, and rendered innocent. Obſerve the eventual importance of thoſe briſker currents of air we call winds, how they bring effluvia from very remote regions, to mix with and counteract others; they purge the air, and occaſion it to de-

poſit

poſit whatever it is loaded with; like the tides in the ſea, they prevent putrefaction; and, like the ſea too, they diſperſe the commodities of one country into other parts of the globe: they bear thouſands of ſeeds of thouſands of plants, and ſow them where elſe they would not be. If they ſtrip our plants, they bring us others in return; and, without our aid, and often againſt our endeavours, all ſpecies of vegetables are preſerved; and not a tribe, perhaps, ſince the deluge, is extinct.

Theſe are beneficial operations: but we know, that in this happy land, we ſee Nature in her beneficent diſpoſition: elſewhere, what we term rain, would be thought a dew,—what we call wind, would be deemed a zephyr. What are our heavieſt rains to thoſe at the equator? where, uſually, during night, the brooks ſwell to rivers, and rivers to ſeas; where the talleſt trees which admit of climbing, ſcarce bear ſome benighted wretch above the deluge around him; whoſe rapid torrent paſſes on to ſwell thoſe immenſe rivers, whoſe diſcharges *freſhen the ſea!* What is our moſt tremendous ſtorm to a hurricane? of whoſe deſolating effects we have frequent accounts from our Weſt India iſlands. HURRICANEs are preceded by the appearance of a ſmall cloud, cloſe to the edge of the horizon, like a ſmall black ſpot, to which the Portugueſe firſt gave the name of the *ox's eye:* this, as it advances, increaſes to the ſize of a hand, and enlarges as it approaches: all this time a perfect calm reigns over ſea and land; all is huſh and quiet: as it comes nearer, the mountains emit a hollow murmur from their cavities, as if dreading the iſſue;

beaſts and animals ſeek ſhelter where they may, and fearful expectation enwraps all around. When the cloud we have juſt mentioned arrives at the zenith, all is inſtant darkneſs and confuſion; the ſun, which this moment blazed with meridian heat, is now, as it were, extinct; midnight darkneſs prevails, or, if interrupted, yields only to tremendous gleams of lightning, broad-ſpreading in every quarter; the wind is terrible; the rains deſcend like waters from a cataract, very offenſive in ſmell, and leaving behind them a moſt noiſome ſtench. Theſe hurricanes ſeldom laſt very long, nor are they often very extenſive, but form a path in their courſe, which is marked with devaſtation; on either ſide of which is no ſign of their power, nor do they in general exceed certain latitudes and longitudes, or violently prevail at ſeveral places in the ſame year: their uſual time is the month of Auguſt, a little before or after. It is remarkable alſo, that if the ſeamen lay by their wet clothes for a day or two, they are found ſwarming with little white maggots, brought by the hurricane. Our firſt mariners were greatly diſtreſſed by theſe dreadful viſitants; and by endeavouring to uſe their ſails; &c. were frequently wrecked. Now, they ſtrip their maſts of every thing which may catch the wind, and, under their bare poles, patiently abide its fury. The Indians adviſed them to this: the Indians alſo had the foreſight, whether hurricanes would happen or not; this they predicted from the appearance of the atmoſphere, at certain periods of the moon: of ſuch utility is obſervation and philoſophy, even among unlettered ſavages! On the coaſts of Guinea theſe hurricanes often happen, three or four in a day, laſting ſometimes

times a few minutes, ſeldom (when ſo frequent) beyond an hour.

What think you now, LADIES and GENTLEMEN, of a hurricane? but what think you of a hurricane *from all quarters at once?* from every point of the compaſs? beating direct on the diſtreſſed mariner: Heaven help the diſtreſſed! Thunder, lightning, rain, raging billows roaring louder than the tempeſt, daſhing in ſparkling foam over the tormented veſſel, obey not mortals, but only Him, who "rides in the whirlwind, and directs the ſtorm." From theſe terrors no part is free; they meet in one central ſpot, and, with circular rapidity, enlarging their ſphere, every moment, they increaſe in dimenſions and power, ſweeping all around into havock, deſolation, and ruin. Such is a TORNADO!

It requires extenſive judgment, accurate information, and capacious ideas, to perceive the benefits ariſing from ſuch convulſions of nature: their terrors aſtoniſh us into abſence of mind, and we dread them too greatly to ſuppoſe their utility: —but, doubtleſs, they have their utility; and were they employed only in tranſporting that immenſe ſwarm of animalcula with which they abound, from the countries where they are bred, to the ſea where they are deſtroyed, the inhabitants of thoſe climates could never be ſufficiently grateful. Let us but recollect that many of theſe parts, as it is, are uninhabitable by reaſon of ſuch ſwarms, whoſe annoyance is inſupportable: let us add the immenſe prolificneſs of theſe inſects, what number of eggs they depoſit, how often, how early they breed, and we may well imagine, that were even hurricanes

and

and tornadoes ſuſpended for one year only, that year would be peculiarly marked with calamity:—with calamity! with a PLAGUE. The very name inſpires trembling and alarm; yet from no greater cauſe than a corrupt air, occaſioned by ſuper-abundant inſects, has that ſcourge of mankind originated. Whatever taints the air, and ſuper-ſaturates it with putrid vapours, engenders diſeaſe, which, by the addition of a certain ſomewhat (not well known to us), becomes epidemic and contagious. The atmoſphere is the ſeat of the plague; but whether it originate in the atmoſphere, or ariſe from the earth, we cannot preciſely determine. Experience teaches, that though the malady be ſmall at firſt, it ſoon increaſes, every freſh infection propagates the diſorder, every patient promotes its malignity,—the family is cut off,—the houſes are ſhut up,—the ſtreets forſaken! Tread with caution, for on either hand behold inſcribed, the "Lord have mercy on us!" and liſten to the dreadful proclamation, "Bring out your dead!"

What might diſpoſe it to ſuch a ſtate, is not eaſy to determine; but it was notorious, that during the great plague of London, in 1665, "there was ſuch a general calm and ſerenity of weather, as if both wind and rain had been expelled the kingdom." A heated atmoſphere promotes this diſtemper; but a ſcorching, or violently heated atmoſphere, uſually deſtroys it: it is alſo abated by cold, and, by ſevere cold, entirely ſtopped. Agreeable to this, the midſt of Africa never knows the plague; nor the cold climate of the north:—while the fertile provinces of Aſia Minor are annually viſited by it, and

it deſolates the ſhores of the Mediterranean. That the plague has its ſeat in the air, and not in any particular diſpoſition of the patient, ſeems evident from the ſpots and marks with which it ſtains the very mortar of the walls, and other parts of infected houſes.

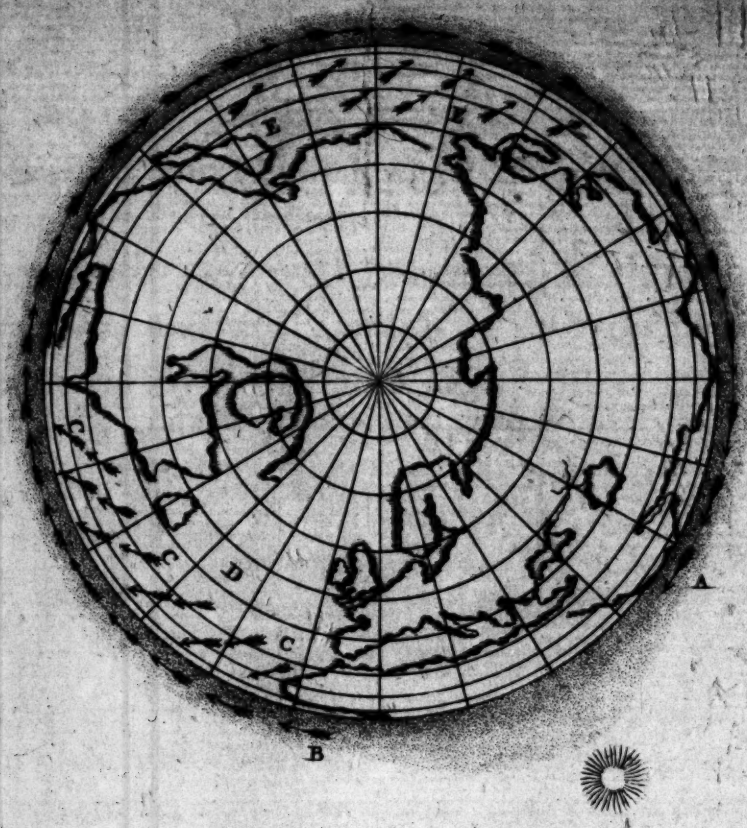
O for a ſtorm,—a hurricane,—a tornado, which, by its force and velocity, may remove the cauſe of this deſtruction! *they* are fierce, but tranſient; *this* ſettled and laſting: *they* deſtroy only a track; *this* defies diſtance and precaution: *they* deſolate a village, or a town; *this* depopulates a kingdom:—yes, and thus it is, wherever we inſpect the operations of nature and Providence, certain evils we find, and of a certain magnitude; but are not theſe the cures to others much greater? or is not each preventative of many? I verily believe ſo: I conceive it is appointed as the general and regular courſe of nature. It is the prerogative of our benevolent Author, to bring good out of evil; and where we can trace him, we perceive him exerciſing this prerogative; where we cannot trace him, we acknowledge, that our ſhort-ſightedneſs is no impediment to his operations; it becomes us to ſubmit our confined ideas to his extenſive wiſdom.

If the ſtorm clear the air, if the cold purify it, if the lightning correct it, though theſe may have their inconveniences, welcome lightning, cold, and ſtorm; nay, if the plague ſweep off thoſe among mankind, who are yet more dreadful peſts of ſociety, we will embrace the plague:—but when we contraſt with what it *might* be, or even with what really is elſewhere,

the

the bleſſings of our own ſituation, where Nature's movements are mild, not violent; and gradual, not vehement; where we know, only by report, the ſufferings of the human race, in their terrific forms,—it may well induce us to think leſs of our actual ſufferings, and add a reliſh to enjoyments which are not contaminated by ſuch bitter ingredients. Far be it from us, becauſe unviſited by theſe terrors, to deſpiſe our placid mercies; becauſe free from theſe awful admonitions, to neglect the milder bleſſings by which Providence is appealing to us, and gently calling our attention, not to tempeſt, but to peace; not to devaſtation, but to bounty.———

Thus the prophet ſtood unmoved, when the mighty wind rent the mountains, and brake in pieces the rocks; and after the wind an earthquake, and after the earthquake a fire: but, at hearing the ſtill ſmall voice, he wrapped his face in his mantle. The raging wind, the trembling earth, the devouring fire, excited not that awe, that devotion, which the mild and familiar tokens of divine appearance impreſſed at once on his enraptured mind.



WINDS.

OBSERVATIONS on the PLATES

Belonging to LECTURE IX.

PLATE I. The upper figure illuſtrates the reaſoning, page 182. If the whole ſuperficies of the globe were ocean, and in conſequence free from impediment or obſtacle, it is probable, that the ſurrounding atmoſphere would be ſo uniformly moved by the ſolar influence, that only one wind (and that following the courſe of the ſun) would ever prevail throughout the globe.—Where the ſun is vertical it is noon, and here the figure repreſents a very conſiderable expanſion of the aerial fluid, which, as the globe turns (B) toward the ſun, puſhes forward thoſe parts of the atmoſphere toward which the ſun advances, they increaſing in heat continually, till the ſun at length becomes vertical, while the parts (A) turning from the ſun, become gradually cooler by his abſence, and the air ruſhes forward to ſupply the progreſſive vacancy following the expanſion; this ſcheme would repreſent the effects, were the ſuperficies of the globe without land; but as it really is, the land checks and changes the courſe of the winds, ſo that they are permanent only on ſuch wide extended oceans as are beyond the influence of the land's attraction, as at C C C, and E E.

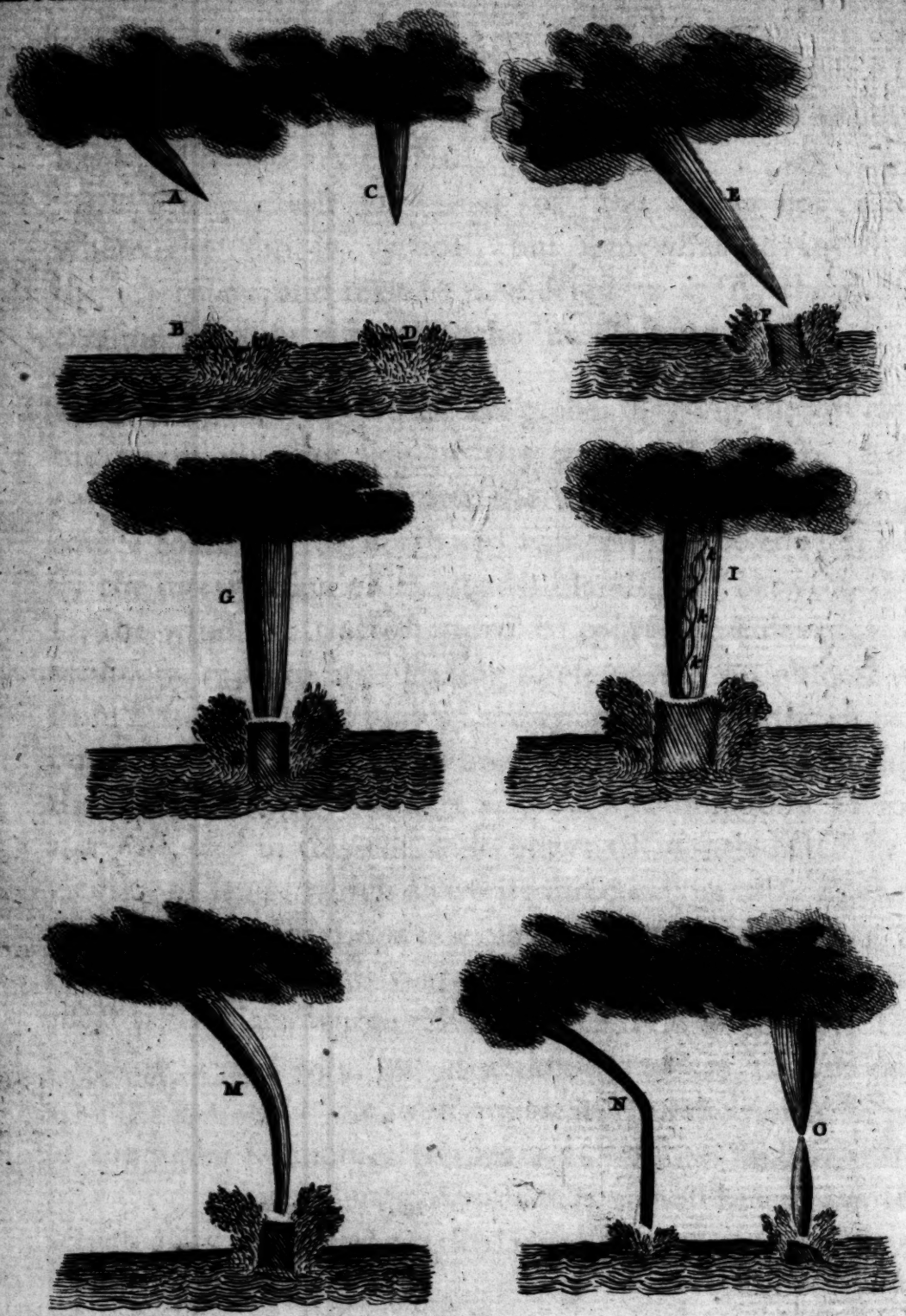
We obſerve alſo, that the direction of the arrows (which ſhews the courſe of the wind) C C C, is not the ſame as thoſe A and B; it gradually becomes aſſimilated to it, while at the diſtance D, the air feels little or nothing of theſe motions,

but is liable to variableneſs and changes from a variety of local and temporary cauſes.

N. B. The greateſt expanſion of the air is not *actually* where the ſun is vertical, but ſomewhat advanced into the afternoon, and may be conſidered as at A, the heat increaſing for ſome time after the ſun ceaſes to be vertical.

The under figure is a view of the globe, ſhewing the courſes of the winds on each ſide of the equator (E Q). A B is part of the great South Sea, the wind blowing ſteadily in a courſe combined of north and eaſt toward the equator; but by the intervention of the lands, iſlands, &c. between C and D, the wind is attracted out of its courſe, and deviates very conſiderably from it. Paſſing theſe parts, we obſerve that from E to F the wind blows ſteadily again toward the equator; but it is from parts where there is no land, which being to the ſouthward, its direction is now a combination of ſouth and eaſt, and in this courſe it blows till contradicted by the vicinity of land: which alters its direction, as at I. G ſhews, that half the year the wind blows one way; H ſhews, that the other half of the year it blows directly contrary. This effect takes place where the ſea may be ſaid to be bounded by projections of land; but is unknown where the occean is widely expanded: the ſouthern as well as the northern parts of the globe ſuſtaining leſs heat, exhibit no ſuch regular or periodical winds, but their cooler atmoſpheres are more actuated by local and particular cauſes and circumſtances.

PLATE



WATER SPOUTS.

PLATE II.

Repreſents the progreſs of a WATER SPOUT, according to the figures of Dr. Stuart in the Philoſophical Tranſactions.

A Is a ſpout juſt beginning, and dipping a little out of the clouds, not perpendicularly down, but obliquely; the water underneath (B) is correſpondently affected, and ſtands like a "little buſh, or moving tree" of water and foam attending the ſpout, and moving with it.

C Is a ſpout darting ſtraight down, and producing ſimilar effects on the water D.

E The oblique ſpout prolonged till near the water, which now ſtands in a compact body, (F) anſwering to the ſpouts.

G The perpendicular ſpout prolonged, and ſtrongly attracting the riſing body of water H.

I A very thick deſcending ſpout, in which the water *k*, *k*, *k*, is ſeen riſing ſpirally till received into the cloud; L is the body of water broader than the ſpout.

M Is a bent ſpout, producing the ſame effects.

N Is a ſpout very much bent, and moving with the wind, the water below following it.

O Shews the breaking and conſequent diſperſion of this phenomenon; the upper part being abſorbed and drawn into the cloud, the lower part falling into the ſea with great noiſe and daſhing. The break uſually begins in the middle of the ſpout by a gradual decreaſe of its dimenſions.

LECTURE

LECTURE X.

LADIES AND GENTLEMEN,

WHEN we examine closely those articles, whose apparent simplicity has determined mankind to consider them as *elements*, we find them little understood, and much remaining to be developed: they may seem simple, uniform, homogeneous; but this rather arises from our inability to pursue their properties through their various minuter subdivisions and branches, than from an actual elementary termination of nature's principles. Of this, our present subject, the AIR, is an instance; which, though it has usually been thought pure and uncompounded, yet is found to include many and considerable varieties; it possesses also many remarkable peculiarities, whose effects are among the most striking and amusing.

It would have been thought formerly a whimsical, if not a stupid opinion, that the air is heavy, yet such is the fact; and were it so applied, a man might as well be pressed to death by a weight of air, as by any other means. It is also compressible into a smaller compass or space, than it naturally occupies; and, on the contrary, is expansible into a larger compass or space than usual; from which principles proceeds its different density, at different heights above the

AIR.

London, Publish'd by C. Taylor N.o 10 near Castle Street, Holborn, Oct.r 1.st 1788.

the ſurface of the earth. The air is a fluid, in ſome inſtances pretty much reſembling water; but totally unlike it, in that it cannot be congealed, or rendered ſolid, or brought towards ſolidity. We can by no means exhibit a lump of air; yet we know that air enters into the compoſition of all ſolid bodies, and perhaps I may even ſay, they owe their ſolidity to it. The oak is greatly indebted to air for its hardneſs; metals and ſtones are partly formed of air, and every ſubſtance of every nature includes this as one ingredient.

The reaſonings of mankind proceed always by compariſon: earth and water are heavy; this our ſenſes inform us, and none ever carried either without acknowledging the fact: but as mankind had no occaſion to carry air, their ſenſes were incompetent to inform them of its weight; nor indeed was it capable of being weighed, till ſome contrivance was diſcovered, whereby a veſſel emptied of air might ſhew a difference from its weight when full. Of late years this has been carried to perfection; and upon extracting the air from any proper ſhaped veſſel, and weighing it before and after ſuch extraction, by the difference of weights we find, that a cubic foot of air weighs upwards of one ounce.

From the foregoing premiſes it appears, that the earth is every where ſurrounded by a ponderous fluid, riſing very high above us: at the bottom of this fluid (eſpecially), are ſeen myriads of creatures, whoſe exiſtence depends upon it, who are perpetually moving about in it, and who, though compreſſed by it on all ſides, are ſo adapted to their ſituation, as to feel no inconvenience from this immerſion. Not only ſo,

but

but change their ſituation, they will quickly complain of inſupportable anguiſh, and only by reſtoring this indiſpenſable fluid, can comfort and enjoyment be reſtored to the ſufferers. Nor is this all, we ſaid, "at the bottom of this fluid" is the ſtation of theſe beings, and to this only they are adapted; for the air becoming thinner in proportion to its height, it becomes proportionally unfit for reſpiration, the functions of life are performed with difficulty, and every exertion is accompanied by pain, weakneſs, and laſſitude: on the contrary, I doubt not, that could we penetrate far below the ſuperficies of our habitation, we ſhould find equal pain and equal imbecility, from the too great denſity of that medium which *ſhould* contribute to the ſupport of life. We cannot breathe in a fluid ſo denſe as water; but deſcending below the ſurface, the air is capable of much further compreſſion and denſity than water.

It is indeed true, that we are happily ſo conſtructed, as not to be exceſſively affected by the ſmaller variations of air to which we are expoſed; yet, if theſe, as is undeniable, have their influence upon us, we may well conceive that by extreme variations we ſhould be rendered uneaſy and reſtleſs, if not miſerable.

The general WEIGHT of the air, is proved, (1) by weighing it as I have aſſerted, in a very nice balance; which is performed by placing in one ſcale a thin glaſs flaſk, whoſe capacity is known, exhauſted of its air (under the Air-pump); counterpoiſe this by grain weights, then admitting the air into the flaſk, it will gradually overweigh its counterpoiſe. The weight of the air is alſo proved, (2) by exhauſting the air from a glaſs goblet (which is eaſily done by burning a bit of paper in it),

then

then quickly turning it mouth downward on water, the water will riſe, and fill the inverted glaſs; and if we attend to the reaſon of this, we ſhall find it to be, becauſe the weight of the air, on the ſurface of that part of the water not covered by the glaſs, preſſes the water beneath it, and forces it to wherever it may find admiſſion: *i. e.* in this caſe under the glaſs.

There muſt however, it is evident, be ſome bounds to the weight of the air; I ſay if we ſuppoſe ſuch a glaſs heightened, and the water riſing, there muſt be ſome point at which it will ſtop, at which the weight of the preſſing air, will be counterpoiſed by the weight of the admitted water; and this is found to be at the height of thirty-two feet of water. In clear words, the weight of thirty-two feet of water is equal to the weight of an equal column of the whole atmoſphere; whoſe height we know to be very conſiderable. This has been experimented by pipes purpoſely made to this length. The ratio of the weight of air to water being known, we quickly find its ratio to any denſer fluid. Thus mercury being fourteen times heavier than water, a column of air will be able to ſuſtain a column of mercury only one fourteenth part the height of the column of water; that is to ſay, about 28 or 29 inches. On this principle barometers are conſtructed; and by this inſtrument we learn, that though the air be always heavy, and nearly the ſame, yet its weight varies, being ſometimes a little more, ſometimes a little leſs. By long obſervation it is found, that the column of mercury does not uſually riſe higher than 31 inches, nor fall lower than 28 inches, the medium is therefore 29 inches and a half.

This motion, or riſing and falling of the mercury, indicates the more or leſs vaporated ſtate of the atmoſphere; for vapours being lighter than air, riſe and float in it, and by occupying more ſpace than an equal quantity of air, they diminiſh the weight of that part where they abound; conſequently, a ſhorter column of mercury may counterpoiſe it. But when the air is free from vapours, its native weight requires a taller column to equal its preſſure.

We have ſaid, a column of mercury of ſuch an height will counterpoiſe a column of the whole atmoſphere of equal dimenſions;—now, if we aſcend to any conſiderable height, we may be ſaid to cut off a portion of the column of atmoſphere (and that the denſeſt part of it), equal to the height we aſcend; it follows, that a proportionate part of the column of mercury may be ſpared, and we actually find, that the mercury will ſubſide nearly one-tenth part of an inch for every hundred feet of perpendicular height; and hereby this inſtrument becomes a valuable method of meaſuring the heights of mountains, &c. merely by its indicating the proportionate weight of the air on their tops.

The moſt wonderful application of the air's weight, is in the engine for raiſing water from great depths, mines, &c. commonly called the fire-engine:—we know that human ſtrength fails and needs recruit, but the buſineſs of this engine ſuffers no ceſſation; if we change human ſtrength for that of animals, they are incompetent to the buſineſs: but the philoſopher, by means of a little ſteam to procure a vacuum in a cylinder, a little cold water to condenſe the ſteam, and the weight of the air upon the top of the cylinder, will

produce the effect desired. In some engines the weight of the air employed is five, six, or seven tons; and with this they give fifteen or sixteen strokes in a minute: so that their powers are very great, and incessant. How little was so capital an application of this principle foreseen by those Virtuosi, who at first amused themselves with considering the just suggested theory of the weight of the air.!

The whole of the earth's surface, as surrounded with air, is covered with a fluid equal to the weight of thirty-two feet depth of water. What a vast weight is sustained by the earth, if the whole atmosphere be thus calculated! But, not to push the matter so far, I shall just hint, that the weight of atmosphere sustained by ourselves, is far beyond what cursory suggestion might conclude; for, it being the nature of fluids to press equally on all sides, every part of us is exposed to this pressure. To raise water thirty-two feet, requires a weight of fifteen pounds on every square inch; we have only to ascertain how many square inches are in the surface of our bodies; and this, multiplied by fifteen, will demonstrate, that we have never less than *thirty thousand* pounds of pressure exerted against us! This weight varies with the state of the air as we have observed; and by this variation we sometimes support three thousand pounds pressure of air, more at some times, than at others. This great difference of the weight of the air, must necessarily affect the animal functions of our nature, and consequently our health. Asthmatic persons, for instance, cannot bear too light an air, since it wants the powers of a clear, dense, elastic air: being therefore less

elastic,

elaſtic, it is incapable of properly actuating the organs of reſpiration.

Obſerve, if you pleaſe, that a clear air being beſt adapted to our natural organs, is the reaſon why we ſuppoſe the air to be lighteſt in fine weather, when it is really heavieſt.—Whereas the fact is, that this air braces our nerves and fibres, and brings them to a due tone, invigorating our whole ſyſtem, and thereby rendering us alert and lively; not ſo much by adding to our enjoyments, as by relieving us from the oppreſſive relaxation which a leſs favourable ſtate of the air occaſions. We are in this view our own barometers, and can as certainly tell every variation of the air around us, as the niceſt inſtrument; though we cannot aſcertain or adjuſt it by a ſcale.

Having excited your reflections, by expreſſing the weight of air we ſuſtain, it ſeems proper here to anſwer the queſtion, by what are we enabled to ſupport this preſſure,---not only to ſupport, but to be inſenſible of it? We move without hindrance, we exert our ſtrength, our limbs, and no impediment from around us forbids our motions. The fact is, the air poſſeſſes a SPRING exactly proportionate to its denſity and weight; thus it gives us help equal to its reſiſtance, which it thereby renders inſenſible; it's weight is, I ſay, completely counterpoiſed by this principle, and therefore its power is null. The proof is eaſy: fill a bladder with air; it reſiſts the air around it equally on all ſides, with the utmoſt preciſion of reſiſtance: place a weight upon it, it gives way; its ſpring is not equal to ſupport that, not being adapted to it, or deſigned for it; extract a little

of

of the air, its ſpring is diminiſhed, the bladder ſinks proportionably. This experiment needs no inſtrument; but under the air-pump, it is uſual to ſhew the weight of this fluid by extracting the air from a thin ſquare bottle,—the preſſure of the outward air on all ſides ſoon overpowers the glaſs. The ſpring of the air is ſhewn, by cloſing a ſimilar bottle full of air, and extracting the air from the receiver around it, the included air finding no reſiſtance from without, ſoon demonſtrates the weakneſs of its priſon, and eſcapes from confinement, by burſting the bottle to ſhivers. The reſiſtance of air, therefore, is proportionate to its compreſſure;---and here we ſee the reaſon why it is more DENSE near the earth, than in its upper regions; becauſe the lower ſtrata of air ſupport the weight of the ſuperior, and have leſs room wherein to be extended.

Though air penetrates every where, ſo that every thing may be ſaid to be full of it, yet it is poſſible to encreaſe the quantity of air in a proper recipient. Thus a hollow globe of braſs is naturally full of air; but if it have a hollow neck united to it by a valve, a piſton may be made to puſh the air of the neck into the globe, till, by continued working of the piſton, the globe ſhall contain twice as much air as before; and this quantity may be augmented till the globe (if it be ſtrong enough) contain twenty or thirty times its original quantity of air. Thus far I myſelf have worked it; but to what degree air might ſuffer compreſſure by farther ſtrength is unknown; a nutſhell might contain the atmoſphere! The cleareſt proof I know of this, is the quantity of air to be extracted from certain ſubjects: a cubic inch of nitre yields *five hundred times* its bulk

bulk of air; reckoning therefore its earth for nothing, the air it contained has ſuffered a wonderful compreſſure, by a proceſs of nature unknown to us. We cannot puſh this experiment to its extremity; human ſtrength, or art, is limited, and ſolid air is beyond our production. Let us therefore turn to the reverſe of this; the air is EXPANSIBLE beyond our conception. We have heretofore noticed the expanſion of air by the heat of the ſun, and to heat we muſt look for the general cauſe of this effect. The force of gunpowder ariſes from expanding air; and all the fatal effects attending theſe inventions of men, are attributable to a little air incloſed in the nitre which forms part of the compoſition. Nay, the force of expanding air may be juſtly thought to ſhake the ſolid earth; and it has been ſaid, an inch of air may be expanded to fill the whole annual orbit of the globe.

Thus have we noticed the general and obvious properties of air; thoſe which we may any day without trouble ſubmit to the teſt; it is heavy, it is alſo compreſſible, and elaſtic; this is proved by that ſimple inſtrument the pop-gun, in which, the air ſuffers compreſſure to a certain degree, but beyond that degree it manifeſts its ſpring by driving the pellet before it.—Theſe principles therefore are capable of proof, without recourſe to expenſive apparatus, and without labour or delay.

The perſonal ſervices we receive from this fluid, are ſo obvious and inceſſant, that they are beyond diſpute: while we breathe, we experience them; it is a friend whoſe kind

offices

offices every moment ſupport us; forbid its admiſſion we die. The weight of the air is thought to be neceſſary to force our juices into circulation, to which its elaſticity may contribute. It is thought alſo to contain a ſpirit, which, mingling with our blood, excites it to induſtry. We cannot indeed determine how it acts; but that it really has very great effects upon our vital powers, is evident. That part of our blood which has juſt received the action of the air, differs greatly in colour from that which has performed the circulation, being of a fine florid ſcarlet colour; while that which returns from its courſe, is of a blackiſh crimſon. This difference ariſes from the admiſſion and admixture of air; but how, or why, exceeds our ability to determine. Air is alſo thought to *cool* the blood.

Beſide the ſupport of animal life, many other benefits are beſtowed by air: flame will not exiſt without air, but under an exhauſted receiver a candle quickly expires; gunpowder will not explode,---ignited wood ceaſes to burn,---without air propagation and vegetation make no further progreſs; neither will ſeeds grow, nor eggs produce young. Putrefaction alſo in great meaſure ceaſes, and it is not too much to ſay, that without air the operations of nature would be checked, if not altogether ſuſpended.

As remarkable an inſtance as any which uſually occurs to our notice, is, the neceſſity of air to animals conſtructed for another fluid, to which all their manners are adapted, and out of which they cannot live. Yet theſe are furniſhed with magazines of air; from time to time they riſe to recruit their ſtock, and if totally deprived of air, the loſs is fatal. Fiſh in ponds

which are liable to be frozen over, die under the ice; but if the ice be broken to permit the inhabitants of the waters to breathe, they remain unhurt by cold.

If animals formed for the waters die without air, no wonder thoſe deſtined to inhabit it, cannot ſubſiſt when it is precluded from them; every branch of nature depends upon this element for ſupport. Plants, as we have ſaid, will not vegetate in an exhauſted receiver. "All plants have within them a quantity of air, which ſupports and agitates their juices. They continually imbibe freſh nutriment from the air, to ſupply the wants they ſuſtain from evaporation. When, therefore, the external air is drawn from them, they are no longer able to ſubſiſt. Even that quantity of air which they before poſſeſſed, eſcapes through their pores into the exhauſted receiver; and as this continues to be diminiſhed, they become languid, grow flaccid, and die. However, the plant or flower thus ceaſing to vegetate, by being ſecured from the external air, is kept ſweet a much longer time than it would have continued, had it been openly expoſed.

"Air is ſtill more neceſſary to the life of animals; there are none found, how ſeemingly torpid ſoever, that do not require their needful ſupply. Many have been the animals that idle curioſity has tortured in the priſon of a receiver, merely to obſerve the manner of their dying. We ſhall, from a thouſand inſtances, produce that of the viper, as it is known to be one of the moſt vivacious reptiles in the world; and as we ſhall feel but little compaſſion for its tortures. Mr. Boyle took a new-caught viper, and ſhutting it up into a ſmall receiver, began to pump away the air. At firſt, upon the air's being drawn away, it

began to ſwell; ſome time after he had done pumping, it began to gape, and open its jaws; being thus compelled to open its jaws, it once more reſumed its former lankneſs; it then began to move up and down within, as if to ſeek for air, and after a while foamed a little, leaving the foam ſticking to the inſide of the glaſs; ſoon after the body and neck grew prodigiouſly tumid, and a bliſter appeared upon its back; an hour and a half after the receiver was exhauſted, the diſtended viper moved, and gave manifeſt ſigns of life; the jaws remained quite diſtended; as it were from beneath the epiglottis, came the black tongue, and reached beyond it; but the animal ſeemed, by its poſture, not to have any life: the mouth alſo was grown blackiſh within; and in this ſituation it continued for twenty-three hours. But upon the air's being re-admitted, the viper's mouth was preſently cloſed, and ſoon after opened again; and for ſome time thoſe motions continued, which argued the remains of life." Such is the fate of the moſt inſignificant or minute reptile that can be thus included. Mites, fleas, and even the little eels that are found ſwimming in vinegar, die for want of air."

We have to remark, that all air is not alike: there exiſts (1.) air *purer* than that which compoſes the atmoſphere; there exiſts alſo (2.) air *lighter* than atmoſpheric air; and (3.) another kind *heavier* than atmoſpheric air. There are yet other varieties; but as theſe diſtinctions are ſimple, and to be eaſily retained in the memory, they may now ſuffice.

That the atmoſphere, as it is the grand repoſitory of vapours, ſteams, and exhalations, ſhould become by thoſe means leſs pure than

than if no ſuch articles abounded in it, is very conceivable, and has long been ſuppoſed; but by what means to procure an air free from theſe impurities, was long a deſideratum. Accident furniſhed what ſearch had miſſed. This kind of air, often termed *dephlogiſticated air*, is yielded by nitre in great abundance, by red-lead in great purity, and has been procured nine hundred times purer than atmoſpheric air. If we inquire its properties and uſe, it is very friendly to flame; a candle recently extinguiſhed, is lighted again by being immerſed in pure air. A candle burns by very much brighter in pure air, and light, in general, becomes more brilliant. But though a candle burns brighter, it burns much faſter; and though pure air has its uſes ſometimes in medicine (as in certain caſes where the lungs are affected), yet did we live always in this kind of air, were our lives merry, they muſt needs be ſhort; vitality might be exhilarated, but it muſt be ſpeedily conſumed. Unable to improve this eſſential of life, we congratulate ourſelves on a ſituation more happily adapted to our neceſſities, by thoſe very cauſes which *ſeem* ſo many impurities. Nay, let us reflect a little, we ſhall find nature taking ſome pains to promote impurities of ſome kinds. The motions of the waters produce a degree of fermentation; alſo the riſing and falling of vapours. A portion of putridity is eſſential to vegetation, probably, therefore, to all life; but, that this may not ſuperabound, nature has reſources for diminiſhing it. Plants abſorb, and, as it were, feed upon putrid matter ariſing from ſtagnant waters, and they breathe out purer air; but they will not thrive (if they will live) in

quite pure air; and thus, though a mixture of impurities be neceſſary, when they predominate, ſtorms and tempeſts are violent methods, as ſhowers, dews, &c. are gentle methods of precipitating them. In fact, it is rather when any one kind of impurity ſtrongly prevails in the air, that it is unwholeſome, than when ſeveral kinds counterbalance each other. Hence, among other cauſes, the benefits of change of air; ſince, by leaving that air in whoſe mixture we have long dwelt, we procure a variety whoſe compoſition is not totally different (that would ſhock us), but in which ſome different principle abounds, whoſe diverſity improves the fluid by which we are ſuſtained.

We have deſcribed another kind of air, as by very much LIGHTER than atmoſpheric air; this is procured from ſteel filings, to which is added water, and ſpirits of vitriol, to corrode the ſteel, and ſet the air at liberty. This kind of air is thirteen times lighter than atmoſpheric air, and with this the balloons were filled: by its lightneſs, therefore, it buoyed up the machine till it aſcended to a region where the air was equally light with itſelf. This kind of air is *inflammable*, and is uſually termed inflammable air. It is really curious enough to ſee a tube, from the bottle containing the ingredients, lighted at a candle, and continue burning ſo long as the mixture furniſhes the air; or if a quantity of this air be received into a proper bottle, it will explode like a piſtol. I have heard it, when the quantity has been conſiderable, make a very loud report. This air is fatal to life, and is often found in the upper parts of pits, caverns, mines, &c. where being unventilated it does much miſchief, eſpecially if by any accident it catches fire.

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A contrary kind of air to the foregoing, is that which is HEAVIER than atmospheric air as 3 to 2; and, in consequence, descends to the bottom of pits, caverns, mines, &c. it is equally fatal to life, and extinguishes flame.—This air abounds in all bodies, is esteemed a bond of their union, and is denominated *fixed air*. It is procured from lime-stone, pot-ash, &c. The largest portion of it is procured from fermenting vegetables:—wines, beers, and liquors of all kinds, receive their pungency, their spirit, from it; for if this air be taken from them they become flat, and insipid. Sugar, put into vinous fermentation, has been found to contain 57 parts out of 100 of fixed air. The Grotto *del Cane*, near Naples, produces this noxious vapour remarkably; it rises in great abundance, to the height of about fourteen inches above the ground. Many thousands of dogs have been killed by immersion in the steam; but the cruel experiment is not now so often repeated as formerly, and perhaps may totally cease, when this vapour is discovered to be among familiar articles. I shall just remark, that upon putting the dog's nose within reach of the vapour, he quickly becomes senseless, and, if long so continued, dies; but if withdrawn in time, he recovers by degrees, after being stretched on the grass. How happy is it for mankind that this vapour is not usually in sufficient quantities to do the mischief of which it is capable! Though it destroys life, it stops putrefaction;—ice will not take up any fixed air; water, in freezing resigns all it contained.—This kind of air has its uses in medicine, and is conveyed to the stomach with proper correctors: it has salu-

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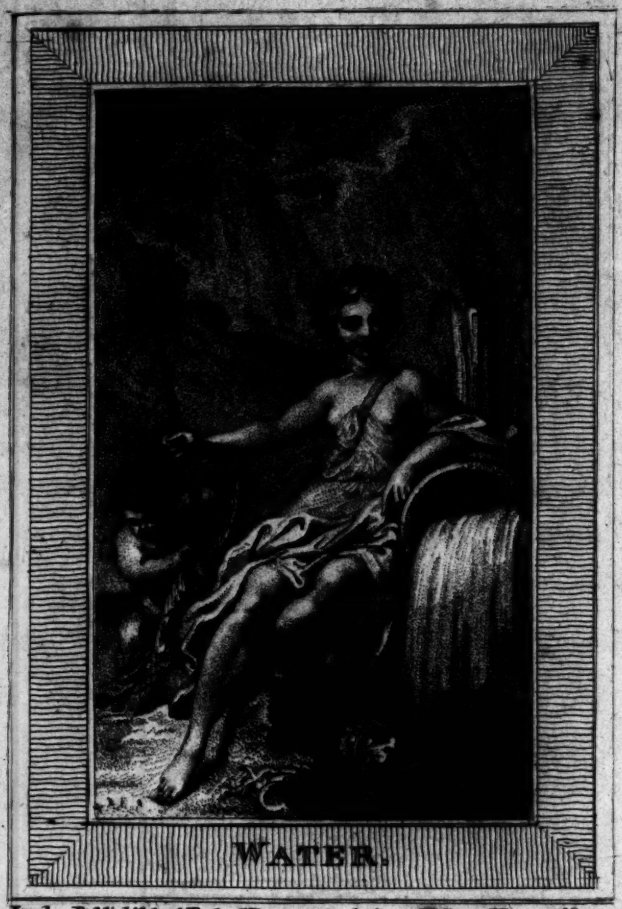
tary effects in the ſea ſcurvy, which is thought to be occaſioned by a want of it; ſeamen's food being of proviſions from whence it is expelled. This kind of air then is as neceſſary to life and to health as any other, and though acknowledged to be by itſelf fatal, yet in union with others is ſalubrious and indiſpenſable: the ſame remark applies to all kinds of air—their miſchief is not altogether in kind, but in quantity and prevalence, or diſproportion.

What a ſeries of ſeeming contradictions have we now been attending to! Air is neceſſary and indiſpenſable to life; it is alſo mortal and deadly,---deſtructive as poiſon itſelf! here it contributes to jucundity, and there it overpowers with torpor; here it riſes and floats, there it ſinks and deſcends; here it is too light, there it is too heavy; here it ſupports flame, there it extinguiſhes it; here it is too pure, there it is putrid; and yet all this is neceſſary! by union, by commixture, by action, and re-action, the whole is tempered, and fitted for its offices. What a providential combination of principles concur to produce the air we breathe! We may judge by the little we diſcern, with what infinite ſkill all nature abounds,---for we ſee but little of her ſecrets, we trace but a few of her operations; could we behold thoſe more auguſt and important, we might think leſs of our preſent knowledge. Yet we muſt be ſenſible, that enough that concerns our well-being is ſubmitted to our knowledge; all that contributes to life, is not neceſſary for us to know; and when, after much reſearch, we hit on a diſcovery, it rather furniſhes a ſubject of admiration, than a neceſſary natural enjoyment; for were it otherwiſe, and that thoſe only who knew the ſecrets of na-

ture were capable of enjoyment, the wiſeſt might lament that ignorance which admitted ſo little ſatisfaction. But Providence has diſtributed to all, that all might render their tribute of gratitude; no one can plead ignorance of this, no ſtation of life is exempt from this. While we readily own that whoever has attained ſuperior knowledge, whether of the cauſes of things or their combinations, whether of their diverſified utility, or their many-operative powers, ſuch an one has much to inform his mind, to entertain his reflection, to amuſe his imagination, to invigorate his underſtanding. Such an one may congratulate himſelf on the advantages of his ſtation, and while without reluctance he admits all as common ſharers in general benefits, let him highly value thoſe attainments which contribute to his individual ſatisfaction and felicity.



WATER.

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LECTURE XI.

LADIES AND GENTLEMEN,

AFTER air we place water; a fluid, whoſe abundance and univerſality, has expoſed it to the ſtricteſt trials and experiments of the moſt accurate philoſophers; who yet have little to boaſt in reſpect of knowing its nature or compoſition, beyond the veriеſt ruſtic who without enquiry ſlakes his thirſt in the ſtream. What we know of it, reſolves into a confeſſion of its powers, its uſefulneſs, and its general diſtribution throughout every part of nature. It is true, this latter idea (its general diſtribution) eſcapes the obſervation of our ſenſes, and eludes the remarks of curioſity itſelf, which ſtartles at the ſuggeſtion, that the moſt ſolid bodies we know are very greatly compoſitions of water!---and yet this is fact. Water is (next perhaps to fire) the moſt fluid body in nature, it penetrates where air is unable, and oozes---not through chinks, but through pores too ſmall for the paſſage of any other fluid. A variety of experiments places this beyond a doubt: and a veſſel impervious to water, is under no apprehenſion of tranſmitting other liquors. We own, indeed, that water is not always ſo ſudden in burſting from confinement as air, which ruſhes out vehemently at once, if opportunity be offered; or as

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quickſilver, which, becauſe of its weight, takes inſtant advantage of the ſmalleſt crevice; but though leſs haſty, it is more certain, and in the end accompliſhes its purpoſe where thoſe fluids fail. Air will not paſs through leather, but water will; a fact uſeful to the negroes of Africa, who cool their water by hanging leathern bottles of it in the open air, the water pervades the pores of theſe bags, and by its evaporation cooling them and their contents, affords a pleaſanter and more refrigerating beverage to the parched inhabitants of the torrid zone. Water will alſo eſcape through a bladder, where air will not; and the famous Florentine experiment informs us, that even the pores of gold are not ſufficiently fine to refuſe this element paſſage.---To examine this, a hollow ball of gold was filled with water, and firmly cloſed, then preſſed with great force by huge ſcrews, till the impriſoned element permeated its confinement, and ſtood upon the ſurface of the globe in the form of dew.

If water be thus capable of paſſing bodies the moſt ſolid, and by the fineneſs and ſmallneſs of its parts, of pervading their receſſes, it becomes evident there is no impoſſibility attending the ſuppoſition, that it may alſo form a part of their compoſition. This is demonſtrable with little labour; for whether we ſubmit to the operation of the chemical furnace, vegetables, in which this principle abounds, or parts of animals, (ſuch as bones,) or foſſils, all yield water: and this ingredient is often ſeparated from its ſubject by a gentle heat. By a little further advance, the hardeſt ſtones, metals, ſalts, and ſulphurs, yield water plentifully. It is true, the fire ſeems unable to treat all

ſubjects

ſubjects with equal ſucceſs, but under the focus of a burning glaſs, the very diamond confeſſes its compoſition, and entirely evaporates. Reflect a little, if you pleaſe, upon this; the diamond, whoſe firmneſs and union reſiſts the hammer, which can be poliſhed only by its own powder, that intractable gem whoſe hardneſs is proverbial, whoſe ſplendour and durability give it in the eyes of mankind a diſtinguiſhed worth; that gem which adorns the fair and enriches crowns, that gem is merely a drop of ſolid water. Bring it to the teſt, it vaniſhes in vapour. After this, we may well admit the opinion of the immortal Newton, that "All birds, beaſts, and fiſhes, inſects, trees and vegetables, with their parts, grow from water, and by putrefaction return to it again." It ſeems indeed to be a very powerful and indiſpenſable bond of union, deprived of which, bodies become mere ſhapeleſs maſſes of duſt and aſhes.

The idea of water being a very principal component of every body is not new. Thales (the philoſopher who firſt calculated an eclipſe, as formerly mentioned) thought the ſame, and the ſentiment is underſtood to be countenanced by Moſes himſelf. As, however, it is not the antiquity but the truth of a ſentiment, which intitles it to our reception, we may ſafely rely on modern experiments for a proof of the fact. In order to confirm this opinion, Van Helmont made an experiment, by diveſting a quantity of earth of all its oils and ſalts, and then putting this earth, ſo prepared, into an earthen pot, which nothing but rain water could enter, and planting a willow therein; this vegetable, ſo planted,

grew up to a conſiderable height and bulk, merely from accidental aſperſions of rain-water; while the earth in which it was planted received no ſenſible diminution. From this experiment he concluded, that water was the only nouriſhment of the vegetable tribe; and that vegetables, being the nouriſhment of animals, all organized ſubſtances, therefore, owed their ſupport and being only to water. But this has been ſaid by Woodward to be a miſtake: for he ſhews, that water being impregnated with earthy particles, is only the conveyer of ſuch ſubſtances into the pores of vegetables, rather than an increaſer of them, by its own bulk: and likewiſe, that water is ever found to afford ſo much leſs nouriſhment in proportion as it is purified by diſtillation. A plant in diſtilled water will not grow ſo faſt as in water not diſtilled; and if the ſame be diſtilled three or four times over, the plant will ſcarce grow at all, or receive any nouriſhment from it. So that water, as ſuch, does not ſeem the proper nouriſhment of vegetables, but only the vehicle thereof, which contains the nutritious particles, and carries them through all parts of the plant. Water, in its pure ſtate, may ſuffice to extend or ſwell the parts of a plant, but affords vegetable matter in a moderate proportion.

How far water may be purified by diſtillation is doubtful, ſome affirming that after many repetitions of that proceſs, it will yet depoſit a ſediment, while others think it may be freed from every extraneous ſubſtance. No method has yet

yet been diſcovered, which may warrant our aſſerting that we poſſeſs water entirely pure; and it is probable, when ſuch a diſcovery ſhall be made that (like air), more ſorts than one may be found. This is certain, as various airs by commixture are rendered fit for the ſupport of animals, and as without ſuch circumſtance air would be uſeleſs or noxious; ſo the element of water, in the ſtate nature offers it, is moſt fitted for the uſe of thoſe who are to profit by it. We have already ſeen that vegetables ſuffer by too great purity of water; and the ſame effects, in a conſiderable degree at leaſt, might be thought to follow, were any perſon to drink diſtilled water only.

Of the wholeſomeneſs of water, experience muſt be judge, ſince the inhabitants of different places find that to which they have been accuſtomed (and which ſometimes looks far from inviting to a ſtranger), both agreeable and healthful.

It is common to put water to the teſt, by trying whether it will form a lather with ſoap, or whether it will curdle; and this is thought a diſtinction between hard water, as it is termed, and ſoft water. But hard water becomes like ſoft water upon expoſure to the air. Thoſe waters are in general lighteſt which have feweſt diſſolutions floating in them, but no water is to be obtained without ſome, according to the ſtrata through which it has run: and I well remember, having procured ſpecimens of water from ſeveral ſprings in different parts of London, all of them extremely

 clear,

clear, yet each of them precipitated a ſediment on the addition of a very ſmall portion of acid of ſugar. This is the origin of all mineral and medical baths, whoſe waters, in their paſſage through beds of metal, of ſulphur, of arſenic, &c. diſſolve a part of the mineral through which they run, and imbibing it, convey it to where they ſpring; that theſe ſhould have ſome qualities which we cannot by art give to water, is not wonderful, when we conſider the unknown and unſuppoſable combinations of minerals in any one bed; to which we may add, that by paſſing through ſucceſſive beds of different ſorts, ſomewhat may be loſt, and a different ſomewhat gained. But of late, the qualities of the moſt celebrated waters have been cloſely imitated, and by the addition of various kinds of air (principally), the ſame taſte, colour, and (ſome ſay) effects, are produced: nay it is not uncommon to make medical waters ſtronger of ſimilar principles, than waters of the natural ſprings which are imitated.

Tranſparency is a very agreeable quality in water, yet muſt not be relied on as a proof of ſalubrity, ſince ſea-water is at leaſt as tranſparent as any. River water is thought, upon the whole, the lighteſt; but we know, that in their courſes, rivers receive many pollutions from various quarters; eſpecially if the courſe of the ſtream be through low and marſhy lands; or if the courſe of any of thoſe ſmaller ſtreams, by which it is enlarged, be through ſuch a channel. A river becomes in its progreſs more polluted than higher up the country, becauſe it receives a ſtronger tincture from the much

much greater quantity of plants, of minerals, of inſects, of animals, &c. than is corrected by its increaſe of water: and thoſe who live at the mouths of great rivers, and drink their waters, are ſaid to be unhappy proofs of this, and ſubject to many diſeaſes in conſequence.

The water of the river Thames is conſidered as ſuperior to all other for keeping at ſea; but even this water has many impurities abounding in it; but what I have heard aſſerted, ſeems I think ſtrange, that water taken up below London-Bridge, with all the pollution of the city in it, is preferable to, and keeps better than if taken up above the Bridge. Shall we ſay that this pollution falls to the bottom, and carries with it much that is worſe? or that it contributes to kill many of thoſe inſects with which all water abounds? Certain it is, that all water by long keeping putrefies, and this moſt probably, by reaſon of thoſe minute inſects, or vegetable ſeeds, which abound in it. But we muſt not ſuppoſe that it is the element itſelf, which thus grows putrid and offenſive, but the ſubſtances with which it is impregnated. It is true, the utmoſt precautions are taken to deſtroy all vegetable and animal ſubſtances that may have previouſly been lodged in it, by boiling: but, notwithſtanding this, there are ſome that will ſtill ſurvive the operation; and others find their way during the time of its ſtowage. Seamen, therefore, aſſure us, that their water is generally found to putrefy twice, at leaſt, and ſometimes three times, in a long voyage. In about a month after it has been at ſea, when

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the bung is taken out of the caſk, it ſends up a noiſome and dangerous vapour, which would take fire upon the application of a candle. The whole body of the water then is found replete with little worm-like inſects, that float, with great briſkneſs, through all its parts. Theſe generally live for about a couple of days; and then dying, by depoſiting their ſpoils, for a while increaſe the putrefaction. After a time, the heavier parts of theſe ſinking to the bottom, the lighter float, in a ſcum, at the top; and this is what the mariners call, the water's purging itſelf. There are ſtill, however, another race of inſects, which are bred, very probably, from the ſpoils of the former; and produce, after ſome time, ſimilar appearances: theſe dying, the water is then thought to change no more. However, it very often happens, eſpecially in hot climates, that nothing can drive theſe nauſeous inſects from the ſhip's ſtore of water. They often increaſe to a very diſagreeable and frightful ſize, ſo as to deter the mariner, though parching with thirſt, from taſting that cup which they have contaminated.

RAIN-WATER is a fluid of Nature's own diſtillation, of whoſe cauſes we have treated; it is more friendly and nutritive to plants than any other; but where rain-water only is uſed by mankind, it is by no means the moſt ſalubrious: though, perhaps, its inſalubrity is in great part often attributable to the reſervoirs wherein it is kept, and to over-long keeping.

SNOW-WATER is drank chiefly, if not altogether, at the feet of

of the Alps, and many other mountains; in Greenland, and in ſome parts of England: to the drinking this water has been attributed thoſe very large, I might ſay frightful, wens, or ſwellings, which disfigure the throats, &c. of the inhabitants in ſome places. But this opinion ſeems erroneous; as they are totally unknown in Greenland, and are common in Sumatra, where ſnow is a phenomenon which never occurs.

SEA-WATER is diſtinguiſhed by its ſaltneſs; and this property of ſea-water has long excited the opinions of the learned, and of courſe has long divided them.—Some think, the rivers imbibing ſomewhat of ſaltneſs from bodies over which they flow, or which they bring down to the ſea, might in time, by leaving ſalts in the ſea, render it ſalt: while others maintain, that the ſea was formerly ſalter than at preſent, ſo great an influx of freſh-water gradually affecting the ocean: a contradictory mode of reaſoning from the former, but equally void of demonſtration or plauſibility. A third party hint at rocks of ſalt, fitly diſpoſed to be diſſolved by the waters (and ſuch we know there are); while thoſe who think the water was created originally ſalt, have much to urge in ſupport of the ſentiment. And probably its degree of ſaltneſs was not very different from what we now find it, for it ſeems, that though certain kinds of fiſhes are adapted to freſh-water, yet their numbers bear little proportion to thoſe who conſtantly inhabit ſalt-water, and who cannot exiſt out of it. If, therefore, theſe fiſhes poſſeſſed at firſt the ſame natures as now, their element was of neceſſity ſalt: this queſtion ſeems therefore decided, without enquiring how far the ſaltneſs of the

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ſea is appointed to prevent its putrefaction;—for it is a fact, that, in ſmall quantities at leaſt, ſea-water the moſt ſtrongly ſalted will putrefy; and thoſe who have been long becalmed in ſultry regions, have witneſſed a ſimilar diſpoſition in the ocean itſelf. On the other hand, it will be admitted, that this is no putrid diſpoſition in the water, but in that immenſe quantity of animal particles, which in ſo many ages have repleniſhed the very ocean. As to the degree of SALTNESS in the ſea, it varies in the ſame places at different ſeaſons, ſometimes at different depths; but in general is found ſalteſt where the ſun is vertical, and the water ſuffers the ſevereſt heat.

It appears from ſome experiments, formerly made in a voyage from England to Bombay in the Eaſt-Indies, that the weight of the ſea-water was greateſt, not preciſely at the Equator, but where the ſun was vertical, and conſequently, as I juſt hinted, where the heat was greateſt. The greateſt weight of a definite quantity of ſea-water, which was obſerved in ſailing from 28 degrees, north latitude, to the Cape of Good-Hope, which is about 34½ degrees ſouth latitude, in the months of May, June, and July, was at St. Jago iſland, north latitude 15 degrees; and the leaſt was at Teneriff iſland, north latitude 28. The weights of equal bulks of Thames water, of the ſea-water at Teneriff and St. Jago, were 659—673½—780½ grains; the proportion of which numbers may be nearly thus expreſſed.—Thames water 1000, —Teneriff ſea-water 1022,—St. Jago ſea-water 1184. By comparing theſe numbers with a table in the Philoſophical

Tranſactions, exhibiting the comparative weight of equal bulks of ſimple water, and of water impregnated with different portions of ſea-ſalt, it may be conjectured, that the Teneriff ſea-water contained about $\frac{1}{32}$ of ſalt, and the St. Jago water about $\frac{1}{4}$ of its weight of ſalt, ſo that it was nearly, if not fully, ſaturated.

This very great proportion of ſalt in the water at St. Jago, ſeems liable to objection; ſince one-fourth of its weight of ſalt is full as much as is yielded by the beſt brine-pits in England, whoſe waters, filtering through rocks of ſalt, may be ſuppoſed to be fully ſaturated. But it is impoſſible to determine, whether ſuch a cauſe might be near, or have any influence on, the water examined as above. In general, ſea-water poſſeſſes about $\frac{1}{32}$ to $\frac{1}{26}$ its weight of ſalt. And this proportion renders it by much more compact, more denſe, and of ſtronger reſiſtance than freſh-water, inſomuch, that I have been told of deeply laden veſſels, which having paſſed the dangers of the ſea, too heavy to float on a thinner fluid, ſunk in port.

It has been debated whether water be COMPRESSIBLE: ſome think they have compreſſed it, ſo that a body of water occupied leſs ſpace than before; but it ſhould ſeem that water ſuffers but little compreſſion, if any, and that if no deceptive appearances miſled thoſe gentlemen who maintain the affirmative, yet ſo ſmall is the effect produced by conſiderable ſtrength, that little ſtreſs can be laid upon it. But when we mention its ELASTICITY and EXPANSION, neither calculation nor imagination can determine its limits.

Water expands by heat; and, what is very extraordinary, it alſo expands by cold: no machine can be invented, no ſtrength can be effectually applied to confine water while freezing. You have often noticed bottles and vials, full of water and cloſely corked, if expoſed to ſeverely cold weather, cracked and burſten: were they made of iron, and an inch in thickneſs, they would experience the ſame event; nay freezing water has been known to burſt cannon. If we ſeek further proof of its power, it appears in thoſe huge fragments of maſſy rocks, which from time to time are ſeparated from their parent mountains, and tumbled from their ſummits: think of their weight, their ſolidity, their ſize, then think of the cauſe which diſplaces them,—a little water, which having trickled through their fiſſures, till united in ſome hollow, is there frozen, and being frozen is dilated, and being dilated refuſes to ſuffer longer confinement, and, if room cannot otherwiſe be made for it, it will rend the very rock.

But it is more uſual to notice the very great expanſive power of water, when by fire it is converted into ſteam: and ſince this affords to mankind a variety of uſeful machines, it may demand a little attention. I ſaid lately, that the weight of air uſed in working ſome of the fire engines was ſix or ſeven tons; this weight is raiſed ſixteen times in a minute with eaſe, by a quantity of ſteam introduced underneath it. This ſteam is not ſuch as *might be*, but little different, if at all, from that of a boiling tea-kettle. Yet we find that one cubic inch of water is expanded into 2900 inches of this ſteam. Now the elaſticity of ſteam increaſing with heat, and the

ſpace

ſpace it endeavours to occupy being proportionate to its elaſticity; and ſince, when equal in ſtrength to the air, it occupies nearly 3,000 times its former ſpace, were it ſubmitted to yet greater heat, it might become five or ſix times more expanſive, and occupy 15,000 or 20,000 times its former ſpace. —This is at rather a low eſtimation. The force of ſteam is taken at three times the force of gunpowder. So far has ſkill employed this element in its ſervice; and ſo far we may depend on its powers. Advancing on theſe ideas, there have not been wanting thoſe, who have endeavoured to account for the phenomena of earthquakes, by conſidering them as water rarefied into ſteam by ſubterraneous fires, and forcing a paſſage in every direction, not impeded (effectually) by the ſolid earth itſelf.

Water poſſeſſes, in common with all fluids, the property of *riſing always to its level*; ſo that be the length of a pipe what it may, the fluid contained in it will ſtand equally high at both ends. This is well known to thoſe who have occaſion to lay pipes over the ſides of hills, &c. for if they can form a reſervoir at a height ſufficient, their buſineſs is over. And thus the water, diſtributed through great part of London from the New-River, after deſcending into the town, would, of its own accord, mount into every ciſtern not higher than the eminence from whence it took its departure. It is true, means are found to make it mount higher; but this is not its natural inclination, but the effect of art. The ſame art appears in that uſeful machine the pump, wherein we ſee the water riſe much above the level of the ſpring which furniſhes it. This

is merely the reſult of the weight of the air, which being taken off beneath the pump, while the other parts of the water's ſurface are expoſed to it, the fluid naturally takes refuge where it meets leaſt reſiſtance; and this effect follows, to ſuch a height of water as counterbalances the preſſure of the atmoſphere, *i. e.* about thirty-two or thirty-three feet.

Water preſſes according to its *perpendicular* height: ſo that the ſame quantity of liquor which is one foot high, and three inches in diameter, if rendered only one inch in diameter, and conſequently three feet high, acquires great increaſe of power by the alteration; and if it was reduced to half an inch in diameter, and ſix feet high, it would become yet more powerful. On this principle a pint of water may burſt a hogſhead; for if the hogſhead be *full*, and the pipe through which the pint of water, attempted to be introduced, be of ſufficient height, the weight of the water *will* make its way, and the veſſel, unable to contain it, muſt yield to its preſſure.

There is a very ſtrange peculiarity of water, by which it riſes in very ſmall glaſs tubes without preſſure, and ſimply of its own accord. If a glaſs tube have two curved legs (turning upward) one only a quarter of the diameter of the other, the water will always ſtand higheſt in the narroweſt: if the diſproportion be yet greater, the difference will be greater alſo. This phenomenon has puzzled the moſt ſagacious obſervers; the attraction of the glaſs to the particles of water, which is predominant and effectual where there is the greateſt quantity of glaſs and leaſt water, ſeems to bid faireſt for ſolving the difficulty.

Water

Water appears under another aſpect very different from any hitherto noticed, and indeed incredible to thoſe who have never beheld it;—I mean in the ſolid form of ICE. I need not, in this climate, prove the poſſibility of this fact. By art we produce ice in ſpite of the hotteſt ſummer, wherever we pleaſe. To account for it is much more difficult. We know it is the effect of cold, but whether cold be a poſitive exiſtence, in this caſe ſuperadded to the water; or whether it be merely the abſence of heat, in this caſe taken from the water, is doubted, and leads ultimately to the intricate queſtion, Whether water be a kind of metal held in fuſion by a ſmall degree of heat, or a natural fluid eaſily congealable? we have no other fluid (whoſe baſe is not confeſſedly aqueous) that freezes by any means ſo eaſily.—But during the very ſevere depth of ſome late winters in Ruſſia, mercury was diſcovered to be frozen; and the experiment has been repeated, by order, at Hudſon's Bay. This, then, is an inſtance of a metallic body, ſolid in a due degree of cold, but rendered fluid by no greater heat than that of the general temperature of the air. This diſcovery is thought in ſome degree analogous; and hints, that cold exiſted before heat, and that by heat all things (probably the very air included) were liberated from their bondage of inanity, and brought to that order and propriety in which we now enjoy them. I might further obſerve here, that ſea-water freezes equally with freſh, but requires ſomewhat ſtronger cold to produce ice: which ice is not ſalt, like its parent water, but freſh; the ſaline parts of the fluid remaining unfrozen. Salt-water ice thawed, and expoſed a due time to the air, makes

good

good freſh-water.—[N. B. It would deſerve attention whether this water alſo became corrupt, and purged itſelf in keeping.] Water loſes ſomething in freezing, *i. e.* its fixed air; and ſomething it ſeems to get, becauſe it is increaſed in bulk,—but what we know not.

Water, gradually heated, gradually extends its bulk till it boils; but beyond boiling no art can force it. The phenomenon of boiling water is accounted for, by adverting to the admiſſion of heat, and to the expanſion as well of the water itſelf, as of the air included in it. That it does not riſe higher than it does, ſeems owing to the weight of the air which depreſſes it; for take off this weight by an air-pump, and we ſee water exhibit every appearance of boiling, at a degree of heat very much below what it requires in the open air. And indeed I once found, by working an air-pump briſkly, that it boiled ſtrongly when its heat (to judge by the time it had been under the receiver) was very moderate.

The heat of boiling water is a fixed point: no fire can make it hotter; it may accelerate its evaporation, but cannot augment its bulk, or its heat. The certainty of this point, which is the ſame all over the world, under the frozen coaſts of Greenland, as under the torrid zone, renders it highly valuable; and the eaſe with which it may be procured, is a great advantage attending it. And thus we are beholden to water for a determinate ſtation in a ſcale of calculation, which human ingenuity has contrived to enlarge and extend to thouſands of articles and circumſtances.

Is there not further reaſon ariſing from *this* ſubject alſo,

for

for the remark, that " when we examine closely what mankind have agreed to call *elements*, we find them little understood, and much remaining to be developed?" and the reason strengthens, when we ask, What is the composition of water? It has been said lately, to result from union of two kinds of air, the pure and the inflammable. On attending an experiment made in support of this opinion; the receiver was first clear and pellucid; as the inflammable air burned on the orifice of a tube introduced within it, the inside of the receiver became covered with drops like dew; these enlarged, and coalesced, till they ran down the sides of the glass; but whether, by any means, atmospheric air might contribute water; whether the water was discharged from the ingredients which yielded the airs, and existed in, or combined with, those airs, and only became visible upon combustion, deserves consideration. From the general fineness and permeability of water, its intimate union with all bodies, and its notorious disguises, I think we must determine with caution. I have since heard, this experiment has been repeated with all possible precautions; a gigantic apparatus, a sea of mercury, and *electric* fire: the result was the same; the combustion produced water.

But whatever be the composition of water, its utility is beyond denial: as the original and natural drink of mankind, it possesses advantages no other can equal; since, by the fineness of its parts, it passes those minute channels which are impervious to other liquors; and since it is totally free from any disposition to inflammation. Nor ought it to be considered as a slight obligation we are under to this element, that it tends

to health, and comfort, as it contributes to cleanlineſs; that it is cooling, and refreſhing in its nature. In reality, the Turks ſeem not greatly beſide the mark, when they preſcribe againſt the hyp "flouriſhing plantations, ſtreams of water, and ſocial beauty." For be it remembered, that without water plantations would fade; very few ſhrubs can endure the thirſty deſart, but no trees; and wherever flows a ſtream, near it vegetation thrives. We had a proof of theſe principles in St. James's Park, where many of the trees, being deprived of their uſual refreſhment, when, ſome time ſince, the canal was regulated, and partly filled up, they withered and died.

The importance of this article being admitted, it is time to ſhew, that nature is no niggard of this neceſſary: on the contrary, almoſt every little hill, or riſing-ground, in ſome places, has a ſpring; and we find water every where below the ſurface of the earth. In fact, the abundance of water is the greateſt impediment to working mines of any conſiderable depth, and it is frequent to meet with more than one ſtream, or branch of a ſtream, or collection of ſprings at leaſt, in extenſive ſubterranean galleries. And this happens let the *depth* be what it may; we have never yet *bored* the earth ſo deep, but we have had reaſon to think water-ſprings, perhaps rivers, were below us.

As to the natural cauſes of ſprings and rivers, the theory of Dr. Halley ſeems at preſent to be generally aſſented to; and when we reflect, that in treating ſuch comprehenſive principles, we muſt, of neceſſity, reaſon from a part to a whole, and determine of what we do not ſee, by analogy to what we

do

do ſee; we deny not that every hypotheſis of every kind, may in ſome of its parts be liable to objection, and yet, on the whole, it may be natural, juſt, and philoſophical. Dr. Halley ſuggeſts, that the vapours which are exhaled from the ſea, and driven by the winds upon land, are more than ſufficient to ſupply not only plants with moiſture, but alſo to furniſh a ſufficiency of water to the greateſt rivers. For this purpoſe, an eſtimate has been made of the quantity of water emptied at the mouth of the greateſt rivers; and of the quantity alſo raiſed from the ſea by evaporation; and it has been found, that the latter by far exceeds the former. It was determined, upon receiving ſuch rain as fell in a year, in a proper veſſel, fitted for that purpoſe, that, one year with another, there might fall about twenty inches of water upon the ſurface of the earth, throughout Europe. It was alſo computed, by Mr. Mariotte, that the river Seine, from its ſource to the city of Paris, might cover an extent of ground, that would ſupply it annually with above ſeven millions of cubic feet of this water, formed by evaporation. But, upon computing the quantity which paſſed through the arches of one of its bridges in a year, it was found to amount only to two hundred and eighty millions of cubic feet, which is not above the ſixth part of the former number. Hence it appears, that this river may receive a ſupply brought to it by the evaporated waters of the ſea, ſix times greater than what it gives back to the ſea by its current; and, therefore, evaporation is more than ſufficient for maintaining the greateſt rivers; and ſupplying the purpoſes alſo of vegetation.—In ſupport of this theory, it is obſerved,

ſerved, that ſprings are rarely, if ever, on the ſummits of mountains, but on their ſides, a little way down, thereby giving the waters room to collect; that the greateſt rivers originate from the higheſt mountains, they attracting, ſtopping, and condenſing the clouds, which, yielding to them their contents, furniſh ſources for the moſt copious ſtreams; that where there are moſt clouds, are the higheſt mountains, the moſt rapid torrents, the greateſt, and the longeſt rivers.

It ſeems further ſupported, by the peculiarity attending that immenſe ridge of mountains the Andes: on one ſide, they ſcarce know rain; a few clouds, now and then, are their diſtant viſitants—here, riſe gentle brooks, rills, and rivulets, which meander through the grove, and ornament the plain.—But on the other ſide the Andes, prodigious maſſes of clouds are perpetually forming, beating againſt the rocks, beſieging, as it were, this barrier, which forbids their paſſage, and tormenting, with ſtorms, this boundary placed by Nature. What is the conſequence? At many hundred miles from the ſea, riſe thoſe floods which are rivers at their origin, and which receiving many like themſelves, roll on, in one united deluge, to the ocean. While, therefore, this cauſe ſeems adequate to the purpoſe, we ſhall not incline to that theory, which ſuppoſes ſubterraneous waters furniſhed by the ſea to be raiſed into ſteam, and ſo converted into ſprings: ſince it moſt fails where moſt wanted, *i. e.* in accounting for the origin of the greateſt rivers, which are always fartheſt from the ſea, and moſt highly elevated.

It is not uncommon, elſewhere, for rivers which riſe near each

each other, to iſſue widely different; and in our own country, the ſprings which furniſh the Thames and the Severn, riſe at no very great diſtance from the ſame place.

With regard to the nature of rivers, we obſerve, that in whatever direction the ridge of the mountain runs which furniſhes the ſtream, the ſtream itſelf takes an oppoſite courſe; never following the bearing of the land from whence it iſſues.

As to the uſual laws of motion in rivers, they are chiefly as follow:—[*Vide Guglielmini del fiumi.*]

All rivers have their ſources either in mountains, or elevated lakes; and in their deſcent from theſe, they acquire that velocity which maintains their future currents. At firſt their courſe is generally rapid and headlong; but is retarded in its journey by the continual friction againſt its banks, by the many obſtacles it meets to divert its ſtream, and by the plains generally becoming more level as it approaches towards the ſea.

If this acquired velocity be quite ſpent, and the plain through which the river paſſes be entirely level, it will, notwithſtanding, ſtill continue to run, from the perpendicular preſſure of the water, which is always in exact proportion to the depth. This perpendicular preſſure is nothing more than the weight of the upper waters preſſing the lower out of their places, and, conſequently, driving them forward, as they cannot recede againſt the ſtream. As this preſſure is greateſt in the deepeſt parts of the river, ſo we generally find the middle of the ſtream moſt rapid; both becauſe it has the greateſt

greateſt motion thus communicated by the preſſure, and feweſt obſtructions from the banks on either ſide.

Rivers thus ſet into motion almoſt always make their own beds. Where they find the bed elevated, they wear its ſubſtance away, and depoſit the ſediment in the next hollow, ſo as in time to make the bottom of their channels even. On the other hand, the water is continually abrading and eating away the banks on each ſide; and this with more force, as the current happens to ſtrike more directly againſt them. By theſe means, it always has a tendency to render them more ſtrait and parallel to its own courſe. Thus it continues to rectify its banks, and enlarge its bed; and, conſequently, to diminiſh the force of its ſtream, till there becomes an equilibrium between the force of the water, and the reſiſtance of its banks, upon which both will remain without any further mutation. And it is happy for us that bounds are thus put to the eroſion of the earth by water; and that we find all rivers only dig and widen themſelves but to a certain degree.

In thoſe plains and large vallies where great rivers flow, the bed of the river is uſually lower than any part of the valley. But it often happens, that the *ſurface* of the water is higher than many of the grounds that are adjacent to the banks of the ſtream. If, after inundations, we take a view of ſome rivers, we ſhall find their banks appear above water, at a time that all the adjacent valley is overflown. This proceeds from the frequent depoſition of mud, and ſuch like ſubſtances, upon the banks, by the rivers frequently overflowing;

and

and thus, by degrees, they become elevated above the plain; and the water is often ſeen higher alſo.

Rivers, as every body has ſeen, are always broadeſt at the mouth; and grow narrower towards their ſource. But what is leſs known, and probably more deſerving curioſity, is, that they run in a more direct channel as they immediately leave their ſources; and that their ſinuoſities and turnings become more numerous as they proceed. It is a certain ſign among the ſavages of North America, that they are near the ſea, when they find the rivers winding, and every now and then changing their direction. And this is even now become an indication to the Europeans themſelves, in their journies through thoſe trackleſs foreſts. As thoſe ſinuoſities, therefore, increaſe as the river approaches the ſea, it is not to be wondered at, that they ſometimes divide, and thus diſembogue by different channels. The Danube diſembogues into the Euxine by ſeven mouths; the Nile, into the Mediterranean, by the ſame number; and the Wolga, into the Caſpian, by ſeventy.

It often happens that the ſtream of a river is oppoſed by one of its jutting banks, by an iſland in the midſt, the arches of a bridge, or ſome ſuch obſtacle. This produces, not unfrequently, a back current; and the ſtream having paſſed the arch with great velocity, puſhes the water on each ſide of its direct current. This produces a ſide current, tending to the bank; and not unfrequently a whirlpool; in which a large body of waters is circulated in a kind of cavity, ſinking down in the middle. The central point of the whirlpool is always loweſt, becauſe it has leaſt motion: the other parts

are ſupported, in ſome meaſure, by the violence of theirs; and, conſequently, riſe higher as their motion is greater; ſo that towards the extremity of the whirlpool muſt be higher than towards the centre.

It might be ſuppoſed that bridges, dams, and other obſtacles in the current of a river, would retard its velocity. But the difference they make is very inconſiderable. The water, by theſe ſtoppages, gets an elevation above the object; which, when it has ſurmounted, gives a velocity that recompenſes the former delay: Iſlands and turnings alſo retard the courſe of the ſtream but very inconſiderably. Any cauſe which diminiſhes the quantity of water, moſt ſenſibly diminiſhes the force and velocity of the ſtream.

The rivers run to the ocean; to the ocean we now accompany them: it is among the ſublimeſt objects of Nature. Solemn and grand, if calm, ſmooth, and ſerene, it plays its variouſly refracted tints of changing greens, and blues, and greys, as the light falls upon it, or ſhadows of clouds, &c. or if it be agitated by furious winds, and roll its buoyant eddies forward to the ſhore, roaring as they advance, hiſſing as they retire, ſeeming ready to overwhelm the very earth, yet yielding and changing their direction at every obſtacle.—It fills the mind with ſenſation! Human ſkill has availed itſelf of this element alſo, proud and licentious though it be, fickle and unſtable, wild and unreſtrainable, yet we plow the waters, and we navigate the ocean. It is, perhaps, the greateſt of human triumphs! a ſtriking demonſtration of the ſuperiority of reaſon, which chooſes the beſt adapted means to accompliſh

compliſh its purpoſes, and rules even one ELEMENT by the aſſiſtance of another.

A few remarks on ſome peculiarities of the ocean ſhall conclude the preſent diſcourſe.—Water being that fluid which more immediately and conſtantly comes under our obſervation, exhibits phenomena, here eſpecially, of which ſolutions are deſirable. I doubt not that all fluids are affected by the ſame cauſes; and were we adequate to the obſervation, we ſhould find them alſo yielding to extraneous impulſes, as water is well known to do; but we have no equal aſſemblage of any fluid apparent on the face of the globe (whatever may be confined in its interior parts), and air, by its tranſparency, eludes our utmoſt vigilance of remark. We ſhall endeavour to explain the cauſes which influence the motions of the waters, by conſidering (1.) the TIDES, (2.) the SURF, or SURGES of the ocean.

I begin by remarking, that to render the tides obſervable, a very great body, or ocean of water, is neceſſary; there are ſeveral lakes, not unjuſtly denominated ſeas, where the tide makes no appearance; ſuch is the Caſpian Sea, of which it is reported, that though it receives one large river (the Wolga), and many ſmaller, yet its waters always maintain the ſame level (*i. e.* for the myſtery is very ſolvable; admitting the fact, the quantity of water drawn from it by evaporation, equals that which is brought into it by the rivers). The Black Sea alſo has no tides; nor the Baltic Sea, that very large collection of waters. In the Mediterranean, a ſlight kind of tide is felt in ſome places, at ſome times, very irregular,

and only diſcernible by diligent obſervation, as it impedes no kind of buſineſs, nor puts any body out of his way. But in thoſe capacious beds of water, the Atlantic Ocean (on our own coaſts), the Pacific Ocean, and others, the fluid is conſtantly in motion, riſing or falling with very little ceſſation, and this with regular and determinate periods: every ſix hours and a half producing a change in the aſpect of the ſhores. Beſide this, every fortnight the tides are more conſiderable than at other times; and beſide this alſo, at certain periods of the year, they are yet more notorious and extraordinary. It is clear, therefore, that no principle in the water itſelf is the cauſe of theſe changes, ſince it is ſubject to ſuch variety and inconſtant regularity: nor any principle in the globe of the earth, or its ſituations; ſince theſe are not ſo frequently interrupted, but gradually and ſteadily maintain their orderly progreſs. We muſt, therefore, ſeek ſome more diſtant cauſe; *i. e.* among the celeſtial bodies.

The neareſt planet to our earth is the moon; and though but a ſmall body compared with it, yet has conſiderable (always proportionate) effects, which are felt by the whole globe. The ſolid parts of the globe being firm and inſeparable, whatever power affects them, its impulſe is diſtributed throughout the whole, and that proportion of this power, which falls to the ſhare of any one part, is too trifling for us to perceive; but in the fluid parts of the globe, the caſe is different; their ſlight union is eaſily ſeparable, as if every atom were independent. Here, therefore, we may expect, that if any power be exerted, appearances will indicate it;

and

and here we find, in conſequence, the moſt unlimited mutability.

In order to render this mutability more conſpicuous, we will, for a moment, ſuppoſe, that the whole ſuperficies of the globe were covered with water; no iſlands, no capes, no promontories, to check its courſe. It would follow, that whenever the moon was at any ſuppoſed meridian, the body of water would feel her attractive power, and would *there*—immediately *under her*—ſtand, as it were, on a heap: her influence, I ſay, would draw a great body of water from all round about, and immediately beneath her direct and vertical rays, would be the very point of deepeſt water, the apex of the hill of water, ſo to term it. Were the planet's courſe here ſuddenly checked, thus ſituated would things continue. Admit it ſo for the preſent: and ſurvey this globe of water elſewhere. As we recede from where the moon is vertical, toward thoſe parts of the globe to which ſhe is horizontal, we find affairs are totally different; for as we increaſe our diſtance from the *ſeat of the moon*, we decreaſe our depth of water; till being arrived at that part of the circumference of the globe (on the equator, or path of the moon for the preſent time), where we ſee her very obliquely, and at length quite horizontally, the water here is ſhallow, and of leſs depth than it naturally would be: in fact, it is low water. So far all is eaſy, and requires little mental exertion to conceive. But we find alſo, that by continuing our progreſs round the globe (in the equatorial path of the moon always underſtood), the water again gradually deepens; and as we advance toward

that

that point furtheſt from the moon, and where, if we could ſee *through* the ſuppoſed globe of water, we ſhould view *her beneath our feet*; I ſay, as we advance to this point, we find high water again, and another heap of waters aſſembled, forming another hill.

If the attractive power of the moon were always the ſame, at all diſtances, this ſecond high tide could never happen; but ſince this power decreaſes as we increaſe our diſtance from the body of the moon, we ſee that its effects ought to be much diminiſhed, as we are now further from her by the whole diameter of the *globe*; theſe waters being therefore leſs attracted than any other part of this ſuppoſed covering of water, they are by ſo much lighter; and leſs attached to the *globe*; they will therefore, in a ſenſe, *recede* from it, ſo far as they can; and all round about them will proportionably partake of the ſame inclination, and endeavour to aſſemble in one body; not only as being leſs attracted than any which have contributed to form the firſt high tide, but as following the natural courſe of fluids, and endeavouring to maintain an equilibrium.

As the moon proceeds round the earth in her monthly courſe, ſhe naturally changes the ſituation of this afflux of waters; and as by the diurnal motion of the earth ſhe ſeems daily to go round it, the depth of tide we have mentioned, regularly accompanies her; and would always actually appear ſo to do, were it not checked by the following cauſes: (1.) though the waters feel her influence immediately, yet they muſt have ſome time to aſſemble in, and thoſe from

any

any conſiderable diſtance, have ſundry impediments to overcome, ſuch as—the reſiſtance of the water before them—the difficulty of riſing to a level—and their inclination to preſerve the equality of the water behind them. The time of high-water, therefore, in the moſt open places, *follows* the time of the moon's coming to the meridian about two hours. (2) In countries where the coaſts are irregular, that irregularity has its influence; and in rivers, or arms of the ſea, which run far in-land, the time of high-water varies with circumſtances. If the moon took no longer than the ſun to go round the earth daily, the tides would happen every twelve hours; but as a lunar day is longer than a ſolar day, the interval between the tides is prolonged alſo. A lunar day is about twelve hours fifty minutes.

The reaſon of deeper tides happening in ſome parts of the month than in others, is becauſe the attractive influence of the ſun is at thoſe times to be *added* to that of the moon; the reaſon of ſhallower tides at ſome times than at others, is becauſe the influence of the ſun is to be *ſubtracted* from that of the moon. Thus, ſuppoſe the moon alone might raiſe the waters ten feet, and the ſun two feet; when theſe bodies are in conjunction, and their forces conſequently united, they may, together, raiſe the waters twelve feet; on the contrary, ſuppoſe theſe bodies to be at right angles with each other, it will follow that what one would raiſe, the other will depreſs, and eight feet will be the height of the tide.

As the moon is not always equidiſtant from the earth (her courſe not being a circle, but ſomewhat oval), ſhe has ſome-

times more influence than at others; on the ſame principle, the earth not being always equidiſtant from the ſun, that luminary has ſometimes more power than at others: and the perihelion of our planet being in winter, we may in winter expect the greateſt force from his attraction.—The greateſt tides happen about February (before the equinox), and about November (after the equinox), but always dependent on the neareſt diſtance of the moon.

The greateſt tide we know, is that at the mouth of the river Indus; where the water riſes thirty feet.——What an object for Alexander, who had never before ſeen ſuch a phenomenon! but whoſe knowledge was limited to the gentle, and almoſt motionleſs, waters of the Mediterranean! no wonder he thought the ſea deities were by ſome means offended; and endeavoured, by offerings and ſacrifices, to avert impending fury. Suſpenſe, and awe, and curioſity, muſt have agitated the breaſt of this intrepid warrior, who, had he endeavoured to aſſign a cauſe for this event, had little needed to have ſighed for other worlds to conquer,—ſince even his preceptor Ariſtotle, was vexed to find it among things beyond his knowledge.——The moſt remarkable tides are at Tonquin; for here is but one ebb and one flow in twenty-four hours; and twice in each month is no tide, the water being ſtagnant. Theſe appearances were ſolved by Sir Iſaac Newton, with great ſagacity, and by him attributed to two tides entering from different quarters; of each of theſe tides two come ſucceſſively every day, two at one time greater; two at another time leſs; the two greater compoſe high tide; the

two

two ſmaller are the ebb; and the balancing of theſe tides accounts for the apparent interval.

Though the tides are the greateſt inſtance of the mutability of water, yet others are ſuſpected by curious obſervers; and could we contrive inſtruments ſufficiently accurate, we ſhould probably diſcover the ſame cauſes operating in a wonderful variety of effects. I ſhall juſt hint, it has been ſuſpected, that, the kind of madneſs which ariſes from an accumulation of water in the brain, follows pretty cloſely the phaſes of the moon; and as the ſubjects of it are uſually worſe at new, and full moon (the times of high tides), ſome have hinted that a kind of tide takes place in the ſeat of the diſorder.

We have another phenomenon in extenſive oceans, which does not appear in ſmaller bodies of water: I mean, the SURGES, which, in enormous waves, almoſt overwhelm the ſhores. Theſe are moſt frequent about the equator, and ſeem to be occaſioned by the diurnal motion of the earth, which being moſt ſenſible in thoſe parts, has the greateſt effect on the reſtleſs deep. The motion of the globe is ſteady with regard to the *terra firma*. but the buoyant waves being thrown forward by this motion, are impelled beyond their natural velocity, and in conſequence they exert a force upon the land, which contributes, in ſucceſſion of ages, to undermine or overwhelm it. Being thrown forward in one part, they are of courſe taken from ſome other; but this being contrary to their eſtabliſhed law of equality, as a fluid, they are perpetually endeavouring to reſtore the loſt equilibrium, and

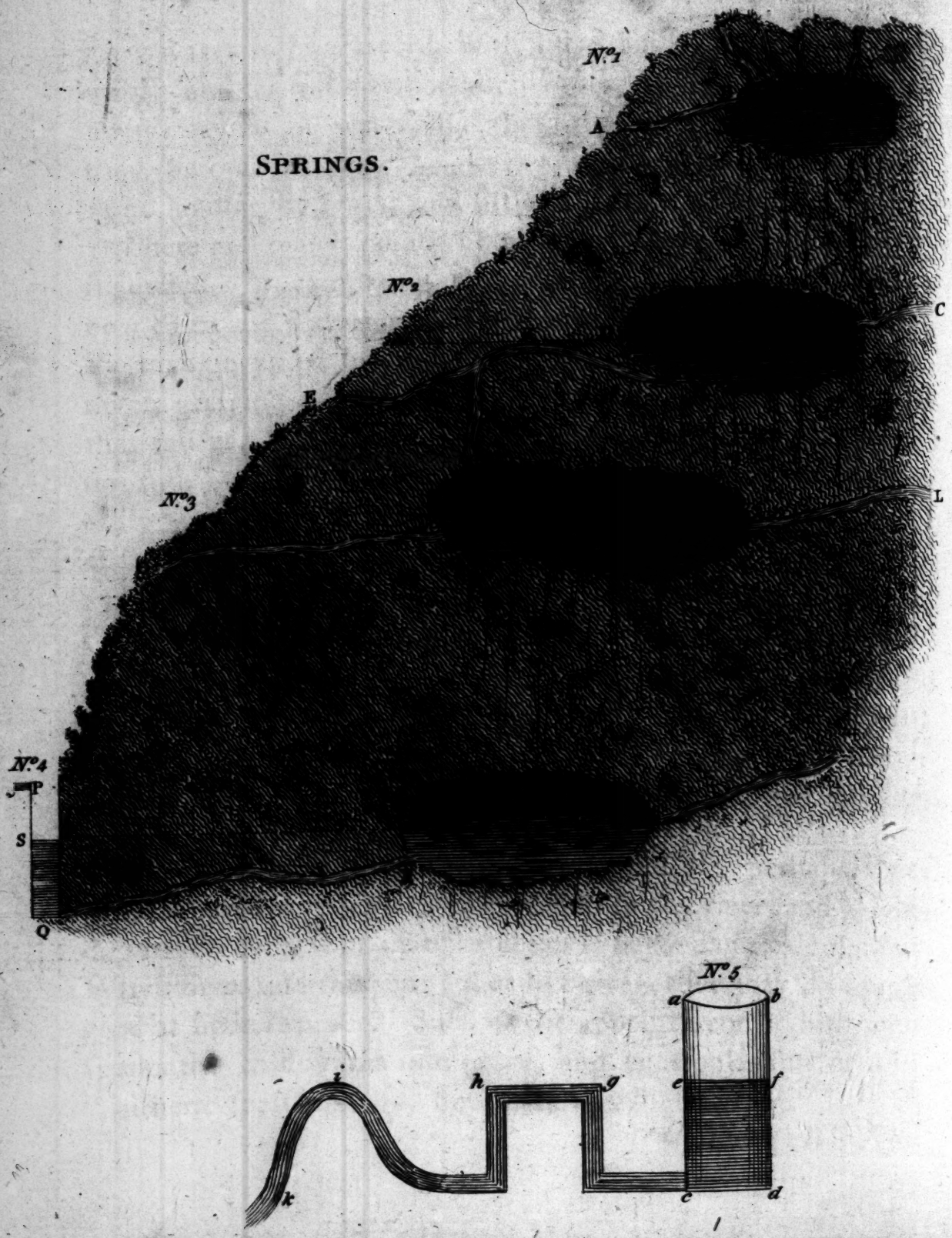
their waves roll backward, with little leſs rapidity than forward; and by rolling upon each other, in the courſe of ſo many leagues of water, by the time they reach the ſhore, they become of great height: and upon theſe ſhores there is no landing by boats, and little ſafety for veſſels.

There are many points of alluſion which moraliſts have ſuggeſted, in comparing the ocean to the human mind; now calm and flattering, now tempeſtuous and ſtormy; ſuch is the man governed by his paſſions!—Or, would they depict a miſer graſping after further additions to his uſeleſs ſtores, they tell us, "all the rivers run into the ſea, but the ſea is not full."—The banks of a reſervoir, or wear of water, are eaſily broken, but who ſhall cloſe them? "The commencement of ſtrife is like letting out of water."—Streams, and brooks, and rivers, enlarge in extent and importance as they proceed; they gladden the thirſty ſoil, they refreſh the drooping plantation, they furniſh beauty to every vegetable; where they flow life is vigorous, and pleaſure abundant; they ſeem indeed to deſtroy, but they really contribute to increaſe; and though a few acres might be recovered were a river annihilated, who would accept the exchange?

Such are the gifts of Providence; partial ills, perhaps, but general benefits: it ſtrikes us evidently in the river, and would do in the ocean, but that the ocean is beyond our calculation. Why ſtorms and tempeſts? that like rivers they may do much good at little expence. Such is the appointment of him who ſpeaks the wild waves into peace, and controuls the ocean; "hitherto ſhalt thou go, but no further."

OBSER-

SPRINGS.



OBSERVATIONS ON THE PLATES

BELONGING TO LECTURE XI.

PLATE I. Repreſents the ſeveral ſorts of SPRINGS, as they are uſually divided into, (1) thoſe which run continually, *i. e.* PERENNIAL; or (2) thoſe which run only at times, *i. e.* TEMPORARY. (3) INTERMITTING SPRINGS, which flow and ſtop alternately; ſometimes very frequently, and at ſmall intervals, by regular intermiſſions. (4) RECIPROCATING SPRINGS, whoſe waters ebb and flow, by riſing and falling alternately. Theſe ſeveral kinds of ſprings are ſuppoſed to be ſituated in the ſame mountain or hill, and a ſection of the ſame exhibited to inſpection.

No. 1. The rains which have fallen on the hill's top, are ſuppoſed to have trickled through crevices, or channels, wherever they could find a way, till at length, ſettling in a baſon, or collection of water, they are diſpoſed to iſſue in a ſtream, and form a ſpring; it is evident, that ſo long as the water in this baſon riſes ſo high as B, it will furniſh the outlet A with a regular ſupply of water, and thus a ſpring may ariſe from the upper parts of any hill whatever: but if the reſervoir be ſmall, or the duct B A be large, this ſpring may fail, or at leaſt be much diminiſhed, without perpetual ſupplies from rains.

There

There is an odd phenomenon of ſuch ſprings ſometimes obſerved, *i. e.* they run in dry weather, and are dry in wet weather; which is eaſily ſolved, by obſerving, that during rain they are gathering waters, and that it requires ſome time for the water to riſe ſo high as B, ſo that, probably, when the rain ceaſes, the reſervoir being full, may iſſue by its channel B. A. and laſt during the dry weather; but be exhauſted again by the time of following rains. The ſame idea applies to Temporary Springs.

No. 2. Shews the principles of Intermitting Springs; which ſprings iſſue from a cavity where the water is collected, and which is continually receiving freſh ſupplies from ſome other ſources, by the channel C. At H, on the lower part of the baſon, is an outlet, H K E, which is of a curved form, riſing at K: here it is evident, that only when the water arrives at the level D K, will it riſe in the channel high enough to run beyond K, and when it riſes to that level, it will continue running through H to K, and ſo on to E, till it has drained the cavity dry: it will then ceaſe of courſe, till the water brought in by C, has again collected to the level D K.

No. 3. Reciprocating Springs, are formed by a combination of the foregoing; for if we ſuppoſe that beſide its own inlet of water L, the ſtream of the baſon, No. 2, inſtead of iſſuing at E, was added, as at M, it is clear that the ſpring O would run conſtantly by the ſupply of water from L, but

would

would run with much greater force and plenty whenever it received the waters of the intermitting ſpring, by means of the conduit H K M; and its times of abundance would anſwer to the periods of the intermitting ſpring.

No. 4. Shews the principle on which water riſes in wells, &c. which is always to that height, S, which is equal to the level of the water in the cavity:—the ſtream running from R to Q, and riſing from Q to S, which is the utmoſt it will riſe to, be the height of the well P what it may.

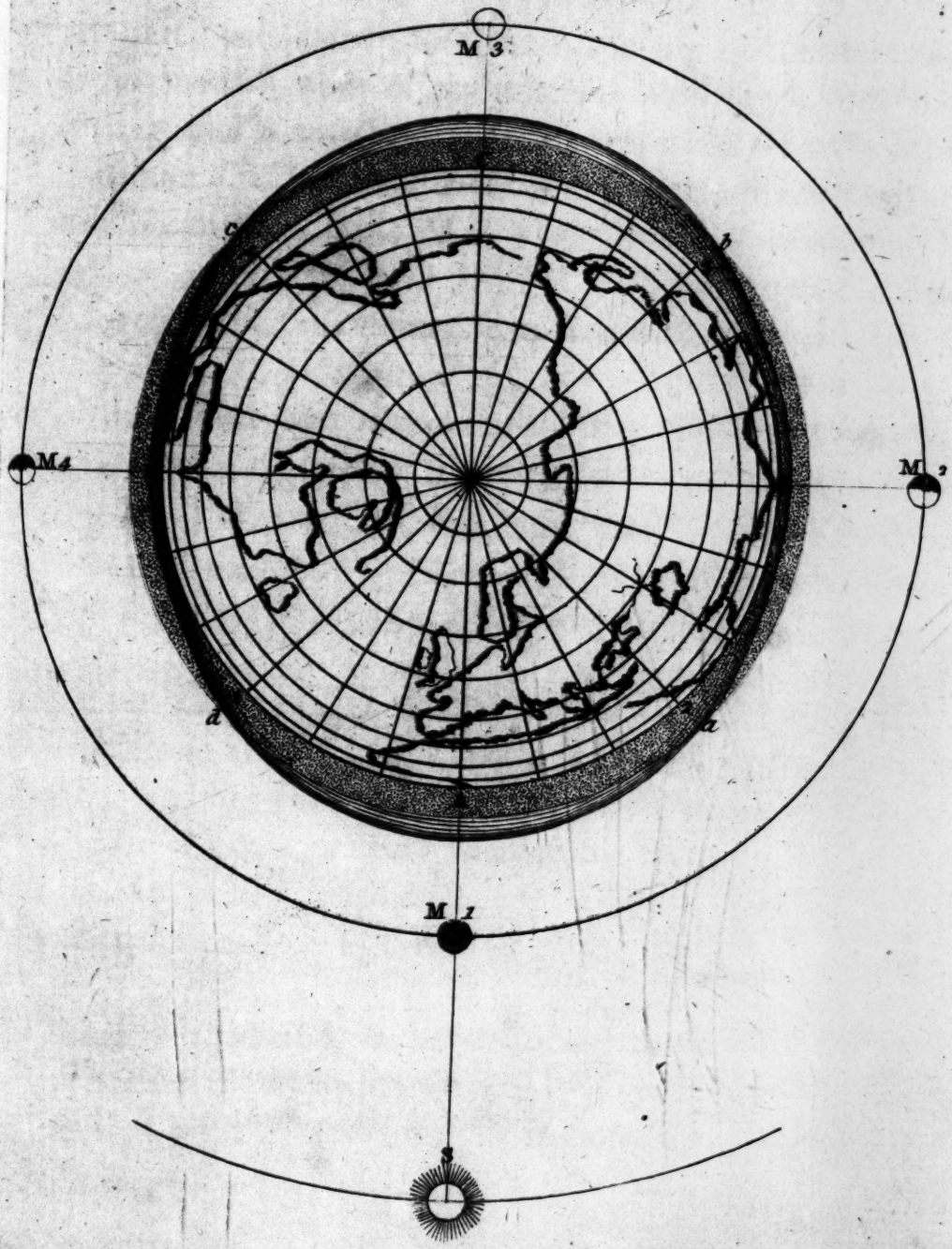
This property of water to riſe to its level, and alſo, in ſome circumſtances to empty itſelf, is explained by No. 5, where *a b c d* is ſuppoſed a veſſel containing water to the level *e f*, from the bottom of this veſſel iſſues a pipe of any form, as *g h i*: the water riſing in this pipe to *g* and *h*, will there run over, and riſe again to its original level *e f*, as at *i*; where it will again run over, and if the pipe *i k* be ſomewhat longer than the depth *c d e f*, the water will run out at *k*, and will not ceaſe, till it has drawn the veſſel *a b c d* dry to the very bottom. This principle affords an inſtrument very uſeful in drawing off many kinds of fluid commodities, called a *ſyphon*; if the ſyphon be inſerted into the veſſel *above* the bottom, it is evident it will draw off the upper parts of the fluid, and leave its ſediment, feculencies, &c. undiſturbed.

PLATE II.—TIDES.

THIS ſcheme illuſtrates the lecture, p. 256. We obſerve, firſt, that were the globe of the earth to be covered with water of any ſuppoſed depth, that water of itſelf would always maintain the ſame level, and form a ring round the globe, as *a b c d*. This would be little, if at all, ſenſibly changed, by any effect of the diurnal rotation of the earth; but ſome ſmall effect would ariſe from the attraction of the ſun, S, which would conſtantly draw together thoſe parts of the water adjoining where it was vertical, as at A: and this riſing of the water would follow its verticality in its daily courſe, but the immenſe diſtance of the object S, being ſo many millions of miles, would render this tide very trifling. But if a celeſtial body, as M, be ſuppoſed pretty near to the earth, the influence of ſuch body muſt needs be very conſiderable.

M 1 is the moon in conjunction with the ſun, conſequently, the combined forces of theſe bodies, have now the greateſt effect on the fluid element. Immediately beneath M 1, as at A, the waters appear aſſembled to the greateſt depth, and gradually become ſhallower as we advance to *a*, which is the point of genuine depth of water; it being here neither

TIDES.



ther elevated nor depreſſed. But as we proceed to B, we find the water becoming lower, having loſt ſo much of its quantity as the depth at A exceeds its juſt proportion. If we take the other ſide of A to *d*, and ſo on to D, we find the ſame occurrence, ſo that this entire hemiſphere, D A B, feels the influence of the planet, and contributes, more or leſs, to the aſſembling of the waters at A. In the other hemiſphere, B C D is an exact counterpart; for at the furtheſt poſſible diſtance from M 1, *viz.* C, the waters being lighteſt, are aſſembled, and here is high tide again: the points *b c* being the true depth, and B D low water.

It is clear, that by the rotation of the earth, the object M 1 will conſtantly appear to change its ſituation; and alſo, that the depth of water, as A, immediately beneath it, will accompany it: and the correſponding depth, as C, anſwer to that; always keeping the greateſt poſſible diſtance.

It is clear alſo, that let the path of the moon be where it may, whether in the equator (as in this figure), or north, or ſouth of the equator (as we know the moon varies even from the ecliptic 5°), the water will aſſemble in north or ſouth latitude, in perfect obedience to its lunar directreſs. Theſe principles need no figure to illuſtrate them.

As the moon proceeds in her monthly courſe round the earth, ſhe muſt, in advancing from M 1, gradually quit her conjunction with S, and take the ſtation M 2, which is the firſt quarter:

quarter: here the tides riſe leſs than before, becauſe the attraction of S, inſtead of adding to the power of M 2, counteracts it; drawing the waters from B toward *a* and A.

When the moon arrives at M 3, it is clear ſhe attracts that part of the waters C furtheſt from S, and therefore leſs attracted by him; conſequently ſo much lighter, and by ſo much more eaſily yielding to her impulſe.—In the other hemiſphere, the ſame occurs at A; theſe waters, of their own accord, would riſe high, but this height is much augmented by the added impulſe of S. Here we ſee the reaſon of higher (or *ſpring*) tides, at new and at full moon; as alſo of *neap*, or lower tides, in the quarters.

M 4, being merely a counterpart of M 2, is explained by that article.

The annual augmentation of the tides, as depending on thoſe conjunctions of the ſun and moon when *ceteris paribus* they have moſt power on the earth, is eaſily conceivable from principles heretofore advanced in the Lectures.

LECTURE

EARTH.

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LECTURE XII.

THE viciſſitudes and changes to which our planet has been ſubjected, have very greatly, I might almoſt ſay totally, altered its appearance; ſo that its original compoſition is now to be inferred, and gathered (and ſometimes ſuppoſed alſo) from circumſtances which occur but ſeldom, from facts collected with much care and ſedulity, or ſought with eagerneſs and hazard, wherever ſome chaſm ſeems to hint a probability of ſhewing nature free from thoſe diſguiſes which are her cuſtomary attire. On the ſurface of our globe, what works, what undertakings, are in perpetual progreſs; from propoſition and commencement, to completion; from completion, to ruin and decay. It is true every animal is by himſelf diminutive; yet the united, or the ſucceſſive efforts, of animals, produce no trivial effects in the appearance of their general mother. Some dwell deep in dens, ſome burrow ſuperficially, ſome excavate the very rocks; all while they live, conſume part of her productions; when they die, they yield a ſomewhat which furniſhes freſh productions for ſucceſſors. What has been the conſtant employment of man (eſpecially) during ſo many ages? to till the ground; to increaſe the nobler ſpecies of vegetables for his own uſe, or pleaſure, or that of the animals he has ſubdued to his ſervices: hence barren

heath

heath has been covered with verdure, cultivation has fertilized the very ſands; hence woods of various natures planted, hence rivers regulated, hence canals created, hence waters collected in ſome places, drained in others; here he wants pools, there he forbids marſhes; here he deepens a haven, there he repels the ſea, and reſtrains it by a dyke.—What a change of the face of nature around ſome opulent metropolis! the bowels of the earth are ranſacked for riches or ornament; and what was buried in obſcurity, now gleams in the face of day. Theſe are occurrences ſo notorious, ſo regular, and ſo conſtant, that to convince ourſelves of their veracity, needs only the uſe of ordinary obſervation.

But there are yet more potent principles, which effect at a ſtroke, more than all the ſucceſſive efforts of mankind, and which, with unabated vigour, with inceſſant aſſiduity, engage punctually in their employment; no change of object, no diverſity of opinion, no attention to other concerns, divert them from their uſual occupation: ſuch are the elements we have already treated on, AIR and WATER. Every ſtream of air which ſweeps over the ſurface of the earth, carries with it much which is not ſtrong enough to reſiſt its force: is there a ſtraggling atom of earth? it is whirled away, now here, now there; this ſpot is deprived of it, that it augments, and trifling as this may appear, the perpetual repetition of it has great effect: producing barrenneſs where was fertility, and fertility where was barrenneſs. Nor is this all; for the air, by the conſtant operation of vapours, ſhowers, rains, ſtorms, tempeſts, performs, by the agency of

theſe

theſe meteors with rapidity, what to itſelf alone would be tedious. Who has not ſeen, after a heavy rain, the very ſurface of the upper grounds conveyed to the lower? evident in ſtreams running over its ſurface, in the diſcoloured water of ditches, of brooks, of rivers.—The ſame event occurs even on the mountain tops, which by repeated rains are gradually diminiſhed. If theſe ſcarce-noticed cauſes produce in time ſuch extraordinary effects, we cannot but attribute yet greater powers to the waters of the ſea, whoſe reſtleſs agitation opens or fills, deepens or ſhallows, gulphs, bays, havens, ports, wherever it has admiſſion. If it is ſaid, theſe cauſes are ſuperficial, let us examine beneath their operations,—this is ſcarce, if at all poſſible, deep as we dig, we find the traces of water and its power:—the endeavour is hopeleſs, and rendered more hopeleſs, when we advert to the operations of earthquakes, of ſubterraneous fires, of volcanos, and to many other probable principles, whoſe concealment is no impediment to their exiſtence deep in the globe. Under theſe embaraſſments, how ſhall we diſtinguiſh elementary earth? Or is there, or was there ever, one ſimple earth, the parent of all others, whoſe abundant principles furniſhed thoſe varieties which now perplex us? Rocks are earth, equally with ſand or clay; yet the obdurate Alps of granite, ſeem little allied to the crumbling duſt of the ſand-pit: and who will ſuppoſe mines of metals, gold, ſilver, lead, tin, &c. not to mention ſalt, coals, ſlate, and many others, who will ſuppoſe theſe to be merely ſeparations from any original parent? And to which, among thoſe we are acquainted with, ſhall we at-

tribute patriarchal honour?—I conſider it as labour loſt to examine this queſtion cloſely: could we ſolve it, ſmall would be the advantage; and probability ſeems the utmoſt extent of our reſearches. To me it ſeems probable, that earths of various kinds were originally appointed to compoſe the habitation of man; but the earth to which he ever was, and ever will be, under the greateſt obligation, is that which furniſhes vegetables with proper ſupport: which opens the enfolded ſeed, nouriſhes the tender germ, ſupports the riſing plant, and matures the important product, whether ſalubrious or uſeful, whether for nutrition or for convenience.

Chymiſts, indeed, diſtribute earths into ſeveral claſſes, according to ſuch of their properties as they are acquainted with; and it muſt be owned that this diſtribution has many advantages; but it is not eaſy to ſay which of theſe claſſes is (naturally) ſimple and pure earth; ſince, when ſubmitted to the teſt, they furniſh a variety which proves they are compoſitions: and this variety conſiſts, not only of different earths, but of other elements; of air, and water, we know; why not alſo of fire?

The moſt ſtriking property of all earths is, that they are capable of *vitrification:* that being ſubmitted to various degrees of fire (ſome of which are highly intenſe) they liquefy, and run into a kind of glaſs, more or leſs tranſparent, more or leſs hard, of various colours, and ſo on. This has induced ſome perſons to imagine, that the whole earth was once a fluid of burning matter, not unlike glaſs; which, as it cooled, became at length fit for the reſidence of animal and vege-

table

table life; it is true, ſay they, it was a long time in cooling, —and it continues cooling ſtill:—when (according to this hypotheſis) it ſhall be quite cold, ſhall the general conflagration enſue?

This may ſtand as a ſpecimen of the creative powers of human imagination: Earth is vitrifiable, therefore it has been vitrified;—when it was vitrified, no one doubts it was a ſeat of heat and fire;—right, ſays another, it was therefore a comet; comets are ſeats of heat and fire:—granted, is the reply, if you admit that both comets and planets, but planets eſpecially, were formerly parts of the ſolar luminary, that origin of heat and fire.—Such is mankind! O that ſome happy genius could tell us, by calculation, at what period the next comet ſhall graze the ſolar ſurface, and ſtrike off freſh planets to join the revolving chorus! who would not wiſh to live when that encounter happens! who would not wiſh to riſque a ſituation on that heavenly meſſenger, which ſhall thus ſhock worlds into being! But alas! no mortal has hitherto been favoured with the ſight;—and, ere its next return, mortality ſhall be ſwallowed up of life!

VITRIFIABLE EARTH furniſhes many conveniences and elegancies to mankind; ſince the articles made of glaſs, to name no other, are now numerous among us. But ſome kinds of earth, by being ſubmitted to the action of fire, become merely a kind of crumbling powder, and theſe are termed CALCAREOUS: ſuch are chalks, lime-ſtones, and even marble. GYPSEOUS EARTH forms plaſter of Paris; and has the ſingular property, after it has been burnt to a powder

from the ſtone which furniſhes it, of becoming a kind of ſtone again, by the addition of water, and of ſwelling as it dries: a circumſtance not, as I recollect, belonging to any other ſubſtance. This renders it extremely convenient to form caſts of moulds, &c. as hereby it inſinuates itſelf exactly into every crevice, and becomes an accurate counterpart of the mould which holds it. MAGNESIAN EARTH is diſtinguiſhed by ſeveral properties; this earth is ſeldom (naturally) ſeen by itſelf, but is uſually obtained by ſeparation from others. ARGILLACEOUS EARTH, or CLAY, ſeems coming nearer to that which furniſhes vegetables with ſupport: and yet pure clay has few fertilizing principles to boaſt of, nor do we ever find, in ſuch pits as have been opened, that any kind of verdure covers them, till a proper time has elapſed, and they have acquired a ſomewhat of which before they were deſtitute.

It is not improbable, that all the ſoil in the world with which we are acquainted, has in a ſimilar manner acquired a ſomewhat of which at one time it was deſtitute. It is in vain to refer to any period beyond the flood, as furniſhing an original and native vegetable earth; but it ſeems likely that, ſubſequent to that terrible convulſion of nature, the trees and plants, their leaves, the more tender kinds of graſs, &c. rotted into a pulp and dried by degrees. We are not under the neceſſity of ſuppoſing every ſpot was utterly deſtroyed, none of its properties, or even of its productions remaining; but conſulting probability, we muſt admit, that as now, ſo alſo then, the ſpoils of former vegetables became the ſupport of their ſucceſſors: and this ſeems the true origin of the moſt fertile

tile ſoils:—of ſoils the moſt fertile without human aſſiſtance and art. Such we find in regions where the human foot has never trod; where, during a long lapſe of time, decaying verdure has accumulated, and enriched at its deceaſe the earth which ſupported its life. Here reigns exceſſive luxuriance, and ſuperabundance of vegetation, plant upon plant; below impenetrable, without the aſſiſtance of a hatchet, to open a paſſage, and riſing over head to the very tops of the talleſt trees,—a canopy ſo matted together and interwoven, as to exclude the light of the ſun; and however cleared away at bottom, yet upheld by mutual ſupport at top.—This ſoil is ſo rich, as to require impoveriſhing; and the planter knows, that unleſs he mixes a proper proportion of ſand with the earth he cultivates, his corn, &c. will ſhoot rapidly into height, become rank, and ſpend, in appearance, that ſpirit and ſtrength, which ſhould be its richneſs and value. The very graſs here, riſes to the height of man, and muſt often be burnt to retard vegetation.

From what has been ſaid, it ſeems to follow, that elementary earth is not now within our power: we find indeed, earths of various ſorts, each valuable in its place, and all neceſſary to a complete union and combination.—Some we find rich, almoſt unctuous, others ſteril, dry, hard, and intractable. Some united into immenſe maſſes, ſolid and ponderous; others in ſmall grains, and almoſt atoms, the duſt of the earth! Some we find barren, others fertile,—ſhall we enquire upon what principles then depends fertility? and how far is earth concerned in promoting it?

That

That earth has ſome ſhare in the vegetables it produces, ſeems at firſt ſight evident, from the earth yielded by all vegetables (more or leſs) upon reduction to their principles:—but this ſeems on the other hand contradicted by experience, which aſſerts, that the earth wherein vegetables grow, loſes nothing of its weight or bulk, in a courſe of years; but ſo much as it was when firſt it received the ſeed, ſo much undiminiſhed it continues. This is apparent to a nicety in the orangeries abroad, where each tree being planted in a diſtinct box, the increaſe of earth (by depoſition and decompoſition of the fallen leaves of theſe trees) would be evident; as alſo its decreaſe, if the plant abſorbed it. But it ſhould ſeem, that after allowances made for loſs by duſt, &c. blown from its ſurface, the Great Bourbon itſelf, though, three hundred years old, has not diminiſhed the earth it was planted in.

The repeated ſupplies of leaves, flowers, and ſeeds, with which the trees are annually arrayed, and which they afterward caſt off; together with the perpetual diſſipations of the ſap, whoſe freſhneſs we experience, not only in foreſts, but even in a timber-yard, and for a conſiderable time after wood has been felled; are ſuch conſumptions, as would exhauſt the earth in time, were they furniſhed from her own ſubſtance. If the repeated loppings of thickets and foreſts, were to be all thrown together for ſome ages, they would form piles as high as the mountains themſelves, on which they were cut; and if the earth either produced the woods, or nouriſhed them from her own bowels, theſe would be all

conſumed

consumed by degrees. The mountains, by being constantly undermined, and wasted by the process of so many deep roots, would be insensibly diminished. Their evacuations would sink them from age to age, and the smaller eminences would have been laid level with the plains long ago.

"The earth, which nourishes our forests, sustains no dissipation of its substance, but continues undiminished, like the earth in the box of an orange-tree."

"And yet the orange-tree has acquired considerable accessions of growth; and has likewise produced leaves and fruit repeatedly. These have weight proportionable to their substance; from whence then do they receive it, since the earth continues as heavy as it was at first? The materials of these growths must be imparted from other sources."

This fact has, in other instances, been accurately investigated; the earth previously weighed to a grain, and every precaution taken: the issue has uniformly been the same. We conclude, therefore, that earth only furnishes a convenient and necessary channel, or means of conveyance, to those principles which promote vegetation.—We see, every day, many kinds of flowers, especially bulbous-rooted flowers, without the assistance of earth, but merely as nourished by water, in those glasses which decorate our mantle-pieces; we see them daily flourish in every variety of tint and colour; nor perhaps has it escaped the notice of my auditory, that many family esculents (onions, for instance, especially) will sprout and grow while *hung up*, free from every supposable communication or contact with earth. We have here appealed to

ſubjects with which we are familiar, and which having originally grown in earth, may ſeem to require a connexion with that element, as moſt natural, and moſt neceſſary: but it is with great probability ſuppoſed, that many vegetables growing in the ſea, whoſe leaves appear and ſwim on its ſurface, have never been attached to earth, but may be conſidered as germinating and increaſing in water only. If it is ſaid, that the ſeed of ſuch plants may fall to the bottom, and there firſt unfolding, may originate from the earth, and afterwards be torn from it by currents of water, we grant it may; yet if theſe plants, from this ſuppoſed ſtate of immaturity and weakneſs, arrive at their perfection while floating on the waves, they may, with at leaſt equal juſtice, be deemed the offspring of water as of earth: we know, indeed, that a ſprig of mint (and other plants), after being taken from the earth, will ſhoot out roots and grow in water; but it is with great difficulty ſuch a ſprig can be returned from water to its native bed, with any advantage; it is ſeldom ſuch plants ſurvive the change.—Upon the whole we may, without injuſtice, conſider earth as furniſhing, (1.) a proper bed wherein plants, &c. are depoſited; (2.) heat and warmth in due proportion for maintaining the life committed to its care; (3.) a regular draught of thoſe nutritive juices which it receives from other quarters.

(1.) The *texture* of earth wherein vegetation flouriſhes, is neither ſo ſtrong and hard, as to forbid the penetration of the roots, and their ſmaller fibres; nor ſo looſe and duſty, as to part with ſuch roots by the agitation of gentle breezes; not ſtiff like clay, nor crumbling like ſand; but of a due conſiſt-

ence, and, as one may call it, *temper*. (2.) There are ſoils ſo cold in themſelves, that labour is loſt in attempting to ameliorate them;—theſe are conſequently diſpoſed to barrenneſs: others are naturally warm. But in another ſenſe the earth is *warm*, as it receives and holds, for ſome time, the ardent beams of the ſun, and theſe it diſtributes as occaſion requires; regularly, conſtantly, probably frugally, but certainly effectually, and without reluctance. Were all the heat of the ſun *at once* imbibed by a plant, it would parch and conſume it; or if it ſurvived, when the ſtock was exhauſted, what penury would follow! But the earth, gradually warmed by the ſolar beams, imbibes them; and when the ſun is withdrawn during night, yet maintains warmth around its plants till the ſun returns: and this kind office it continues, till the plants, having reached maturity, fulfil the reaper's hope. (3.) On much the ſame principle, the diſtribution of rain, &c. by the earth is beneficial: a flood of rain does much leſs ſervice than if it were gentle, becauſe it runs off the earth ſoon, rolling ſuperficially over it: whereas gentle rain gradually ſinks to a proper depth in the ground, rendering it a kind of reſervoir, from whence the plants, by their roots, may draw ſufficient moiſture for a conſiderable time.

That the intervention of the earth is neceſſary, appears from what has been juſt obſerved; chiefly as it affords a kindly-adapted medium and paſſage to thoſe principles of vegetation, of which itſelf furniſhes but a diminutive ſhare;—every element, perhaps, partakes in the formation of a vegetable; air is notorious, water is very abundant, earth has ſome ſhare; and without

without fire, no plant would arrive at maturity, would ever ripen or be compacted.

We admire the productions of the earth; and we dwell on their characters, and qualities: the lofty tree and the beauteous flower, the ſturdy oak and the fragrant roſe; but we ſeldom reflect on the near alliance between them and ourſelves. I was perhaps wrong in ſaying, "our greateſt obligations are to that earth which ſupports vegetables;" ought I not rather to have ſaid, that earth which compoſes ourſelves? which in mankind exhibits every varied excellence, every ſtriking beauty, which ſparkles in the eye, or glows on the cheek, exalted beyond the capability of flowers, were lovelineſs only regarded: but if ſocial manners, and affections mild, adorn this exaltation, what has not earth to boaſt of? Or, when conſtancy and courage, genius and ſkill, depth of thought, of reſearch, of underſtanding, connect with a little earth, in what is the lofty tree, the ſturdy oak, comparable to this? We have ſeen that earth of itſelf can produce no plant, can form not a blade of graſs; barren and vacant alone, but the means of production and ſupport to all things; and, when commiſſioned, it becomes the reſidence even of thought and intelligence. See what ſupreme Power and Skill can do! But though we do right to admire theſe effects, we may reaſonably hope to behold infinitely greater wonders, when this clothing of earth ſhall quit us; when we ſhall return to earth what for a little while we had borrowed; and when the clay, whoſe medium is now neceſſary to communicate our ideas, our ſentiments, our conceptions,

ſhall be deemed no longer worthy our reſidence; for, though wonderfully wrought and formed, replete with contrivance and ingenuity, actuated by, and actuating a thouſand ſprings, all aſtoniſhing in their conſtruction, in their effects, in their compoſition, in their ſympathy, and in their union, yet this fabric ſhall be diſſolved, and earth return to earth, and duſt to duſt.—What! ſhall this compoſition, this terreſtrial maſter-piece of the Divine Workman, omniſcient in wiſdom, ſhall it be loſt, be deemed unworthy admiſſion among his ſuperior exertions of ſkill? No! it ſhall be purified by diſſolution, then be adorned with ſplendor, be ſurrounded with glory, be ennobled with dignity, and then, earth—earth ſhall be honoured among the moſt honourable works of Deity, and perhaps be remarked by admiring angels, as a transformation once unthought of, unlooked for, and now beheld with ſurpaſſing aſtoniſhment, and joyful gratulation!

LECTURE

LECTURE XIII.

LADIES AND GENTLEMEN,

THERE is nothing more difficult, than to confeſs ignorance with a good grace: how often do we ſee hints, innuendos, and even ſhrugs and grimaces, employed to palliate or diſguiſe the abſence of accurate information! and this too, on ſubjects beyond the powers of humanity, where accurate information is little to be expected. There are many things whoſe uſes we enjoy, but their cauſes are hidden; we receive from their ſervices many benefits, but the manner in which we receive them, or their mode of action, is ſecret—this ſecreſy ariſes from various reaſons; either they require for inveſtigation a length of time which exceeds the uſual limits of human life, or at leaſt exceeds that proportion of time and ſtudy which prudence permits individuals to beſtow,—or they are attended with difficulties, or with danger. Who can juſtly expect that mankind ſhould ever fathom the ocean, and explore its receſſes? ſhould diſcover all its inhabitants, their abodes, their manners, their properties, their connections?—Till man becomes an aquatic, very limited knowledge of theſe muſt content him. With equal, with perhaps ſuperior

FIRE.

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rior difficulties, we enter on examination of the element FIRE. It is true, fire is all around us, is neceſſary to our exiſtence; baniſh it we die: on the other hand, collect it, too much overwhelms us with deſtruction: and yet, when we aſk what is fire, who can completely anſwer the queſtion?

I ſhall not profeſs to know, what probably never was, nor ever will be known; but without endeavouring a diſplay of profound and recondite knowledge, ſhall offer a few ſimple remarks, ariſing naturally from the ſubject under conſideration.

I beg you, in the firſt place, to diſmiſs from your ideas of this element, what in reality makes no part of it; *fuel* is not fire: the coals burning in a grate, are conſumed by fire, and they afford ſuſtenance to fire; but it is highly improper to ſay, an element conſumes itſelf, or ſuſtains itſelf.—Our food is not ourſelves, though it is the means of ſupport and prolongation of life. Nor is the *light*, which uſually attends fire, any part of the element itſelf: on the contrary, it may juſtly be ſuſpected, that intenſe light (ſuch as we may conceive, but not ſupport) ſhould rather deſtroy fire.—We ſhall hereafter ſee clearly, that the firſt of theſe poſitions is true. I ſhall at preſent only explain the ſecond. If we can prove that light is not fire; I preſume we may ſafely aſſert that fire is not light.

The firſt inſtance of the ſeparate exiſtence of light is in the lunar rays; which, at full moon, are, as we well know, abundant, ſufficient for the purpoſes of life; they are clear, and not without activity; yet, when condenſed by a

burning glaſs, five hundred or a thouſand times, ſo as to be extremely bright and vivid, they excite no heat, they do not in the leaſt raiſe the liquor in the thermometer.—Reaſon a little upon this,—the moſt ſenſible inſtrument human ſkill can deviſe,—which is affected by the breath, by the approach of the hand, by the moſt ſubtle vapour, yet remains unaffected by a *condenſation* of the lunar rays. Rays from the moon are merely reflections of rays from the ſun; there is no ſuppoſable quality in the moon to alter or change their properties; all it can do is, by the ſphericity of its ſurface, to diverge and expand them; which is merely a ſeparating ray from ray, or introducing diſtance and interval between the reflected rays, but no change in any one ray, conſidered in itſelf: it follows, that rays from the ſun are *light*, and not fire or heat.

Is it inquired, whether, on our own terraqueous globe, there be places where light abounds in regions of cold? we anſwer, many: every mountain-top bears evidence of this; but it is (eſpecially) demonſtrated on the ſummits of exceeding highly elevated mountains. We inſtance, the *Peak of Teneriffe*, a mountain by itſelf, on an iſland. Below, are ſultry expoſures and exceſſive heats; here the labourer faints, here the lighteſt clothing is thought too heavy; cool grots, and ſhady retreats, are here the only enjoyment of life: but aſcend the mountain, the air becomes temperate, then cool, then cold, ſharp, froſty, ſevere.—Here all is winter; here dwell eternal ſnows; yet how abundant is light! Still more remarkable are the tops of the *Andes*, of the *Cordilleras* (in South America); for theſe mountains are ſufficiently large to afford

afford ſpacious plains, and extenſive levels: here is a ſerene ſky, ever blue, ever bright; no cloud riſes to this elevation, nor ever obſcures the ſplendour of refulgent day; never moderates the exceſſive—heat? Oh, no! the warmeſt furs, the moſt ſolid clothing, the winter dreſſes of polar climates, fail here, and ſhivering cold pierces the very bones. Here, if any one dies, the body remains intire, embalmed by perpetual cold; it ſuffers no change, becauſe the alternation of warmth is unknown: and of thoſe who paſs theſe ridges of mountain upon mountain, without paying their lives for the journey, many are maimed; they loſe their fingers, their toes, or other extremities, whoſe diſtance from the fountain of life ſubjects them to a diminution of vital heat.

Ætna, you know, is a volcano replete with the materials of fire; yet high on Ætna ever reign perpetual ſnows. After this, it is little to mention that a friend of mine, in paſſing the Pyrenees, experienced the air "penetrate him through and through:" no defence could prevent the cold.

It is not without heſitation, I introduce the mention of *phoſphoric bodies*, which are well known to ſhine in the dark; ſome of them, by their qualities, ſeem pretty much impregnated with fire, united with light: but there are others, which have no ſenſible property of fire, but ſeem merely lucent. Such is the Bolognian ſtone, and other Marcaſites, which, covered over with their own duſt, and put into a fire, afterwards retain the property of ſhining in the dark. The duſt of theſe ſtones, ſo prepared, if ſprinkled on linen, woollen, &c. ſhines and ſparkles in every form, according to the pleaſure

ſure of its employer; but neither ſets the linen on fire, nor in any manner (that ever I heard of) corrodes, or injures it. —What is more extraordinary, if one of theſe ſtones, thus prepared, loſe its virtue by injudicious expoſure, yet (after a long time), on being laid in the ſolar beams for a few hours, it will ſhine afreſh. Shall we ſay it imbibes a quantity of ſolar beams, which it ſtrongly retains, and viſibly emits when in the dark? *i. e.* in the dark they become viſible by contraſt; perhaps the ſtone is always either imbibing or emitting them; but the firſt we cannot expect to ſee; nor the latter, unleſs all other light be excluded.

There are many natural phoſphoric ſubſtances which ſhine in the dark; ſuch we may conſider glow-worms, rotten wood, corrupting fleſh, fiſh, &c. Art has compoſed a variety of others; and indeed it is found, that from almoſt all ſubſtances, animal and vegetable, the principles of phoſphoric light may be extracted: ſo univerſally is this fluid imparted, one would think it a neceſſary ingredient in their exiſtence and vitality.

It is time now to inquire, whether fire is ever found ſeparate from light? Fire is never found alone, ſo as that we ſhould be able to ſay, this is a lump, or a drop of fire; but always combined with ſome other body. Melted metals, ſuch as lead, &c. are doubtleſs held in fuſion by fire; but melted metals do not ſhine; ſhining, then, *i. e.* light, is no conſtant property of fire; but though its cuſtomary companion, in this inſtance deſerts it. Other bodies, in a ſtate of fuſion, agree with this experiment; the moſt ſolid ice ſubmit-

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ted to the force of fire liquefies, the liquor therefore contains fire; increaſe this quantity of fire, heat the water, boil it,—boiling water does not ſhine: here again fire is without light.

It will be granted, there is leſs fire in water in its natural ſtate, than when boiling, as there is more than in frozen water. This may ſuggeſt the manner how another fluid (the air) is affected by fire, *i. e.* that it always holds a certain quantity, elſe it would perhaps be frozen, but not enough to render its preſence viſible; and even when, by great heat, air may be ſaid to boil, its *motion* is very evident by its tremulous effect upon the paſſing rays of light; but it does not ſhine: and we know that a room may be rendered extremely hot even to ſuffocation, and far beyond the degree of heat fatal to life, yet the air in that room ſhall manifeſt no inclination toward ſhining; nor if we ſuppoſe a ſpectator to examine it, would he ſee any difference in that air whereby to diſtinguiſh that it was replete with fire.

As the atmoſphere may hold a greater quantity of fire, or the fire it contains may be more active, and agitated at one time than at another, ſo it may become ſenſible by its *heat*; I ſay, it may affect us with a ſenſation, which we call heat. Heat and cold are relative ſenſations; what at one time ſeems hot, at another time ſeems cold, according to the temperature of the perſon who judges: heat therefore is the effect of the preſence of fire, as experienced by us. We are our own thermometers, and judge very accurately of ſuch effects.

If the air were always ſtill, motionleſs, and quiet, we ſhould never diſcern its preſence, ſhould never know whether we

we were ſurrounded with ſuch a fluid or not; very poſſibly, we ſhould never ſuſpect the fact; but when air is ſet in motion, we are well aſſured of its exiſtence, though inviſible. Or, when water is equally diſtributed and ſuſpended in the air around us, we are totally ignorant of its ſituation; nor till it becomes viſible in vapours, miſts or clouds, does it come under the cognizance of our ſenſes, and afford proof of its ſuſpenſion and elevation: thus it appears, that our ſenſes are the miniſters of information; we recollect alſo, that to render the tides obſervable, *oceans* of water are neceſſary: had we poſſeſſed only ſtreams, we ſhould have little imagined ſuch an impulſe upon water as produces the tides. We infer, that a fluid, &c. may exiſt unknown to us, unleſs it be ſufficient to excite obſervation by its *quantity*, or unleſs, by ſome *impulſe*, force, or power, a ſmaller quantity acquires ſome property, whereby it enables us to determine concerning it; in proportion to the thinneſs and fineneſs of ſuch a fluid, the probability of our ignorance of its exiſtence increaſes. Perhaps I might with little riſque aſſert, that we are indebted to accident for our knowledge of the finer fluids, ſuch as the electric, the magnetic, &c. as well as for many of the more ſurpriſing properties of thoſe which are our familiar companions.

The fluid, Air, we can feel and hear, but neither ſee, nor taſte, nor ſmell; Water is ſubject to moſt of our ſenſes, to taſting, to feeling, to ſmelling, to ſight; but Fire ſeems to be a fluid, neither to be ſeen nor taſted, nor ſmelt, nor heard, but it becomes our acquaintance through the medium of feeling; by this ſingle ſenſe therefore, accompanied by obſer-

vation and reflection, are we to be directed in our inquiries after the properties and the effects of fire.

If after the endeavours of almoſt all our ſenſes, and after experiments varied almoſt *ad infinitum*, we are obliged to confeſs that the ſecrets of nature eſcape us, that the elements Air and Water are beyond our conception in many reſpects, need we wonder that when, by one ſingle ſenſe alone, we are capable of inveſtigating the element Fire, we ſhould labour under uncertainty or miſtake?

Neither need we wonder, that different opinions on the ſubject ſhould divide philoſophers; that what ſeems plauſible, if not altogether certain to one, ſhould to another ſeem weak and inconcluſive; that the happy ideas of one are eſteemed frivolous by another, and that while wandering each one his own way, that way ſhould appear moſt direct to himſelf, though intricate and perplexing to his neighbour.

From the 14th ſection of Sir *Iſaac Newton's Principia*, we learn, that the motions of ſmall bodies, when attracted perpendicularly towards any ſurface, according to any law, are ſimilar to the motions of the rays of light, with reſpect to the fundamental properties of inflection, reflection, and refraction: from hence chiefly, as well as from other arguments, is inferred, that rays of light are ſmall corpuſcles, emitted from ſhining bodies, and moving with uniform velocities in uniform mediums; but with variable velocities in mediums of variable denſities. This being admitted, it will follow, that in whatever quantity the rays of light are made to move in a medium of an uniform denſity, they will not

agitate the particles, or produce any augmentation of bulk in that medium. If the atmoſphere was reduced to a medium of an uniform denſity, ſurrounding the earth every where to the height of five miles, it would be expanded in bulk, or warmed, only at its outward and inward ſurface. The ſun's rays, by coming out of a *vacuum* into a denſer medium, would be attracted by the particles compoſing that medium; and, ſince all attraction is mutual, they would excite a motion, an expanſion, an heat, at the outward ſurface where they entered: from thence they would proceed uniformly, without producing any effect, till they came to the inward ſurface of the atmoſphere contiguous to the ſurface of the earth, where they would undergo another acceleration of velocity, and would excite another degree of motion, another degree of expanſion or heat. Such an atmoſphere would be coldeſt in the middle, the heat decreaſing from each ſurface. We may, perhaps, from what has been ſaid, conceive, in ſome meaſure, how bodies are expanded, heated, and volatilized, by the agency of the particles of light. Theſe particles act upon the minute conſtituent parts of bodies, not by impact, but at ſome indefinitely ſmall diſtance; they attract, and are attracted; and in being reflected, or refracted, they excite a vibratory motion in the component particles. This motion increaſes the diſtance between the particles; an increaſe of the diſtance between the conſtituent parts of any body, is an augmentation of bulk, an expanſion in every dimenſion,—the moſt certain characteriſtic of fire. This expanſion, which is the beginning of a diſunion of the parts, being

increaſed

increaſed by the increaſing magnitude of the vibrations proceeding from the continued agency of the light, it may eaſily be apprehended, that the particles will at length vibrate beyond their ſphere of mutual attraction, and thus the texture of the body will be altered or deſtroyed: from ſolid it may become fluid, as in melted gold; or from being fluid, it may be diſperſed in vapour, as in boiling water.

According to this theory, we muſt infer, that the conſtituent parts of all bodies are in perpetual motion. The temperature of the atmoſphere is different in different latitudes, and it changes almoſt every inſtant, in the ſame. The temperature of bodies is ever proportionable to that of the ſurrounding atmoſphere, and from thence it muſt be perpetually varying. The bulk of every body is proportionable to its temperature, and muſt therefore be ſubject to a perpetual viciſſitude. Now the body will be in an expanded, in the next inſtant, its heat happening to be diminiſhed, it will be in a contracted ſtate; which variation of dimenſions cannot be effected without a perpetual vibratory motion of its conſtituent parts.

It being eſtabliſhed then, that the rays of the ſun, even in their moſt condenſed ſtate, as in the focus of a burning ſpeculum, do not otherwiſe produce heat than as they excite a motion more or leſs violent amongſt the conſtituent parts of bodies; and the effects of culinary fire, of that produced by friction, or by the impact of hard bodies, being ſimilar to thoſe produced by the agency of the ſun's light, it may be conjectured, that they are produced after a ſimilar manner;

and

and that fire is nothing diſtinct from the parts of bodies put into motion by various cauſes, as the impulſe of light, friction, percuſſion, putrefaction, attraction of coheſion, &c. and conſequently that it may be mechanically produced, altered, or deſtroyed in all bodies, with greater or leſs facility, according as the parts of the body are more or leſs diſpoſed for motion.

This concluſion ſeems to be conſonant with the principles of the received philoſophy. Newton, in his 5th quære annexed to his Optics, aſks, Do not bodies and light act mutually upon one another? that is to ſay, bodies upon light in emitting, reflecting, refracting and inflecting it; light upon bodies for heating them, and putting their parts into a vibratory motion, wherein heat conſiſts?—Such was the opinion of Newton.

Boerhaave thought that fire is a fluid of a nature peculiar to itſelf; that it was created ſuch as it is, and cannot be altered in its nature or properties, deſtroyed or produced; that it naturally exiſts in equal quantities in all places; that it is wholly imperceptible to our ſenſes, and only diſcoverable by ſuch effects as it produces, when by various cauſes it is for a time collected into a leſs ſpace than what, from its tendency to an univerſal and equable diffuſion, it would otherwiſe occupy. All the bodies which are ſituated in the immenſity of ſpace, may, according to this opinion, be divided into fire expanding all other bodies, and into all the other bodies which are not fire, but reſiſt its action. The matter of this fire is not ſuppoſed to be derived from the ſun in any wiſe; the

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ſolar rays, whether direct or reflected, are of uſe only as they impel the particles of fire in parallel directions: that paralleliſm being deſtroyed, by intercepting the ſolar rays, the fire inſtantly reſumes its natural ſtate of uniform diffuſion. Conſiſtent with this explication, which attributes heat to the matter of fire, when driven in parallel directions, a much greater muſt be given it, when the quantity ſo collected, is amaſſed into a focus; and yet the focus of the largeſt ſpeculum does not heat the air, or medium in which it is formed, but only bodies of denſities different from that medium.

The author of the *Lettres Phyſiques* is of opinion, that the ſolar rays are the principal cauſe of heat; but that they only heat ſuch bodies as do not allow them a free paſſage. In this remark he is agreed with Newton; but then he differs totally from him, as well as from Boerhaave, concerning the nature of the rays of the ſun. He does not admit the emanation of any luminous corpuſcles from the ſun, or other ſelf-ſhining ſubſtances, but ſuppoſes all ſpace to be filled with an æther of great elaſticity and ſmall denſity, and that light conſiſts in the vibrations of this æther, as ſound conſiſts in the vibrations of the air; the particles of the one medium exciting, by impulſe upon the organ of viſion, the idea we call light; the particles of the other medium exciting, by impulſe on the organ of hearing, the idea we call ſound. But, as a bell will not of itſelf begin thoſe vibrations by which the air is put in motion, nor continue with equal intenſity the vibrations, when once excited, without the concurrence of ſome mechanical cauſe; ſo neither will the ſun either begin or con-

tinue his vibrations, by which the ſuppoſed æther is put in motion, without a ſimilar mechanical agency. In aſcending from effects to cauſes we muſt ever arrive, upon whatever hypotheſis we proceed, at ſome firſt cauſe, which does not admit an explanation from mechanical principles; this is evidently the caſe in the preſent inquiry. Upon Newton's ſuppoſition, the cauſe by which the particles of light, and the corpuſcles conſtituting other bodies, are mutually attracted and repelled, is uncertain. The reaſon of the uniform diffuſion of fire, of its vibration, and repercuſſion, as ſtated in Boerhaave's opinion, is equally inexplicable; and in the laſt mentioned hypotheſis, we may add to the other difficulties attending the ſuppoſition of an univerſal æther, the want of a firſt mover to make the ſun vibrate.

Thus we ſee, that in every hypotheſis there are difficulties:—for my own part, I think much is to be ſaid for that of Boerhaave;—but then the *univerſality* of this fluid, which he ſuppoſed to be diſtributed throughout ſpace, this I would reſtrain to our globe and its dependencies, and ſuggeſt another fluid as ſupplying its place in the celeſtial regions. I am unwilling to go beyond the limits of our habitation, for thoſe elements which ſeem neceſſary to render it habitable; and if we may ſuppoſe it complete in itſelf, with only one exception, which exception is ſupplied from that magnificent fountain of light, the ſun, I think we approach the neareſt to a juſt idea of the plan adopted by creative wiſdom. But though we ſuppoſe this fluid to be in its natural ſtate, generally, uniformly, and tranquilly diffuſed; yet when a number of bo-

dies of various textures are immerſed in it, it will, like any other fluid, ſelect thoſe to which it is beſt adapted, and which are moſt capable of attracting, of imbibing, and of detaining it. Some will readily receive it, and equally readily diſmiſs it (much as the phoſphoric ſtone we have mentioned, does with reſpect to light); others will not only ſtrongly retain it, but will imbibe a much greater quantity of it, will ſaturate themſelves with it; and when thus *drenched*, as it were, and thoroughly replete with this element, they may well affect the rays of light around them, may attract and excite very large quantities of them, and thus render viſible the fire, by its effects upon the light. For I think we cannot ſay of fire, it ſhines, ſhining being excluſively the property of light; but we not only may, but muſt ſay, that in many inſtances the preſence of fire is manifeſted by light, or that light is ſo affected by fire, as to acquaint us of its companion,

Upon theſe principles may be readily granted, that ſome bodies are more combuſtible than others, that they more freely take fire, may be capable of greater degrees of heat, may hold heat longer, and many other particulars. We advert now to ſome of thoſe effects of fire, which, whether they are deduced from one hypotheſis or another, are claimed by each as favourable to itſelf; and which are ſo evident and conſtant, that none can contradict or deny them, or expect to eſtabliſh any ſcheme to which they are oppoſed.

It is uſually ſaid, there was a time when mankind had no knowledge of fire (and a very ſtrange ſtory is found on the

ſubject in Vitruvius); it is certain, the human body is naturally ill fitted to ſupport too much of this element. It is ſaid BOERHAAVE thought half the diſorders of the ſpecies aroſe from too great a proportion of warmth; and we well know, that thoſe expoſed to the moſt rigorous ſeaſons, are by no means the leaſt healthy, or the ſhorteſt lived; they receive little or no injury from cold only; the viciſſitude of the weather ſeems to be their greateſt enemy. As it was impoſſible that a perſon ſhould rub with any violence, and for any continuance, two pieces of wood together without producing heat (perhaps I might ſuggeſt, as yet ſimpler, the very rubbing of his hands together), if this was to him an agreeable ſenſation, he might eaſily continue it, and by friction excite *flame*; this is done daily among the Eſquimaux Indians, in North America, who, whirling rapidly a piece of wood, by means of a thong, ſet on fire other wood againſt which it turns. One might purſue this train of thought ſomewhat further, might aſk, whether this ſuppoſed original fire-producer conſidered his acquiſition as a friend or a foe, as uſeful or hurtful: was he (as ſome have ſaid the inventor of gunpowder was) the victim of his own diſcovery, or did he happily apply it to moderate the rigours of winter, and to cheer, with ſprightly luſtre, the heretofore gloomy habitation? A word by the bye; man is the only being upon earth capable of producing fire (*i. e.* flame); and the only which knows how to keep it when he has got it: for though many animals love heat, and the oran-outangs in the woods ſurround the fires which the negroes have left, and enjoy their warmth;

warmth; yet they have not ſenſe enough to prolong the fire, by bringing ſticks or leaves to maintain it, though they ſee the negroes do ſo, but ſuffer it to expire contrary to their wiſhes.

Fire, like air, we have ſuggeſted, is diſtributed throughout the globe: like air it is probably extremely *elaſtic*; and alſo very *penetrating*. That it is elaſtic, I think, appears from what we have ſaid of the elements air and water: theſe are highly elaſtic in certain circumſtances, but theſe circumſtances always imply fire; fire therefore ſeems to be the cauſe of their elaſticity—ſurely not without being elaſtic itſelf. As to its powers of penetration, they exceed thoſe of air and water. The poliſhed marble ſides which adorn that chimney, are impenetrable to air, and to water, but not to fire. Obſerve how they begin to be warmed, when the fire in the grate is lighted; as that augments they are heated; and in proportion to the vivacity of the fire, and their expoſure to it, this heat penetrates them, to any ſuppoſable depth.

To penetration we muſt add (ſay ſome) a corroſive quality, whereby like certain acids (aqua fortis, &c.) it conſumes what it ſeizes on; while others think that an intimate and general penetration, muſt needs tend to a ſeparation of the parts of any ſubject. Thus water penetrates ſome kinds of clays, till they become crumbling and rotten; ſhall we ſay it has the ſame effect on wood? What hinders our ſurmiſing that fire penetrates ſo irreſiſtibly, as to perform *ſuddenly* what to other elements requires time, and repetition? But obſerve, that though fire in exceſs may be thought to conſume all

things,

things, yet in moderation its effects vary; ſome it melts, others it hardens, according to what principles abound in the ſubject. Its general endeavour ſeems to be, to looſen all things, to uncombine every combination, and to return the elementary particles to their proper elements, by diſſolving the bond which held them together. Thus metals quit their principles, and by calcination become earths or glaſſes; earths become powders, or run together into fluidity. The principles of animals and vegetables are diſtributed by fire; earth has its ſhare; ſo have air and water: in general, whatever fire thoroughly penetrates, it alſo divides and ſeparates into as minute parts as poſſible.

That kind of fire we are commonly acquainted with, will not burn without acceſs of air; we obſerved formerly, that pure air revived flame; and the proportion of this in atmoſpheric air may well be thought to feed it. A lighted candle quickly expires under the exhauſting receiver of an air-pump, becauſe it quickly conſumes that portion of air adapted to its maintenance and ſupport. The ſame effect invariably attends the precluding of air from any kind of fire, large or ſmall. On the contrary, fire is greatly animated and invigorated by freſh ſupplies of air, becauſe it receives the influx, as well of what fire the air contains, as of that purer kind of air which is ſo greatly its friend. This clearly appears in the effects of the blow-pipe, at the enameller's lamp; but the humbler inſtance of the common bellows proves the point.

A very remarkable property of fire, is the expanſion which it communicates to bodies containing it; this is evident in an

iron

iron bar, or heater; and when it was the faſhion to keep the tea-urn hot by introducing a heater, the dilatation of the iron was an object of familiar remark. The ſame iron which when cold paſſes through a given aperture, when red hot exceeds thoſe limits, and refuſes to paſs. This dilatation, or ſpread of the parts of bodies, which invariably occurs, whether a body be hard or ſoft, light or heavy, may perhaps be eſteemed the moſt certain proof of the preſence of fire, and ſerves to mark its variations within certain limits; it enſues as well from the heat occaſioned by the impulſe of the ſolar rays, as from that of a common fire. Dr. Long mentions his having expoſed a large ſlab of marble in the ſun-ſhine, during the heat of the day, then ſuddenly throwing a great quantity of cold water upon it, it was found, by meaſurement, near half an inch ſhorter in its cold, than in its heated ſtate. This effect of fire is notorious to all engaged in the more delicate parts of clock and watch making, inſomuch that it is neceſſary to correct the too great expanſion of one kind of metal, by accompanying it with another kind of metal, leſs ſuſceptible of the influence of fire.

There is ſomething extremely entertaining in the inſpection of a *Pyrometer*, or inſtrument for meaſuring the degrees of fire; and by this inſtrument we find, as indeed might be expected, that cloſer grained ſubſtances, ſuch as metals, are moſt expanſive; while thoſe more porous, ſuch as woods, are little dilated.

But both metals and woods have naturally their portion of fire, which is ſuppoſed to enter into their compoſition in a compact,

compact, condenſed, fixed ſtate; whereby moſt, if not all its properties are concealed from us; and (as in the inſtance of air, &c.) we ſhould not ſuſpect its preſence, till upon reducing the ſubject to its principles, we find effects not to be accounted for without it. In this ſtate it has been named *phlogiſton.*

Of itſelf, in its natural ſtate of uncombined expanſion, fire is not eſteemed capable of ſhining, or burning; when chemically conjoined with other principles of bodies, it is that alone which conceives and continues thoſe motions by which bodies are made to ſhine, to burn, to conſume away. All bodies are more or leſs ſuſceptible of combuſtion, according to the quantity of this principle which enters into their compoſition, or the degree of force with which it adheres to them. In the act of burning, and it may very probably be during the fermentation, and putrefaction, and chemical ſolutions of various bodies, it recovers its fluidity, is expanded and diſperſed into the air, or combined anew with ſuch ſubſtances as it has an attraction to.

The inſtance of ſulphur is the cleareſt I know: I need not endeavour to prove, that burning ſulphur emits a powerful vapour, offenſive to the ſmell, and to the lungs; every lighted match demonſtrates the poſition. This vapour collected, is the vitriolic acid; but this acid is itſelf incapable of combuſtion, and rather extinguiſhes than promotes flame in other bodies. *Something elſe*, therefore, enabled the ſulphur to burn; but what? no aſhes remain, nor ſoot.—Charcoal burnt taints the air with an offenſive ſmell, but

yields neither watery vapour, nor ſooty impurity; a few white aſhes are all its remains, theſe are incapable of burning; what then enabled the charcoal to burn? Some metallic ſubſtances burn bright, others moulder away rather than burn; moſt of them, when in the open air, ſubmitted to the action of fire, loſe their metallic appearance and become earth. There was then *ſomething* which was ſo combined with ſuch earths, and had ſuch effect upon them, as totally to vary their appearances; this ſomething, is the inflammable principle or *phlogiſton*, never viſible alone, yet ever powerful in combination; and what comes nearer to our point, is capable of extraction from one ſubſtance, and tranſmiſſion into another. It is natural to enquire, reſpecting theſe metallic earths (which nobody indeed would conceive by their appearances to be metallic), can they be reſtored to their metallic forms?—We anſwer, Yes, with little trouble. The earth of lead, expoſed to a ſtrong fire, in conjunction with any body or ſubſtance replete with phlogiſton, will deprive that body of its phlogiſton, and aſſume it itſelf, and acquire all the properties and appearances of lead. And this it will do, whether ſuch ſubſtance belong to the animal or vegetable kingdom, whether it be charcoal or fat, or any combuſtible ſubſtance whatever. The charcoal, &c. will become as if it had been burnt. On the ſame principles, by the union of phlogiſton to the acid obtained from ſulphur, a real ſulphur may be re-produced.

Theſe inſtances may ſuffice to ſhew the actual exiſtence of ſuch a principle, and to ſuggeſt its innumerable combinations.

Whatever we examine, admits more or leſs of this ingredient; as we have ſeen, metal is not metal without phlogiſton, neither is fleſh fleſh, nor a plant a plant, nor water water, nor air air. There ſeems to be one fluid however independent of it, and which perhaps is the great agent in every thing, and on every occaſion, I mean LIGHT; which yet has ſuch relation to fire, or is ſo connected with it, that to mortal eyes they appear the ſame; only diſtinguiſhed and ſeparated by thoſe, who having occaſionally diſcovered them apart, have been induced to examine them under various forms, have traced them through various diſguiſes, and at length have proved them eſſentially different, and in many reſpects diſſimilar.

There is not infrequently a kind of jealouſy when art is exhibiting its performances: the mind naturally ſuppoſes, that the artiſt takes every precaution that his experiments may ſucceed, and fancies that to ſuch or ſuch peculiarity, perhaps *ſingularity* of circumſtances, much of the ſucceſs is owing. I ſay upon difficult ſubjects, ſomewhat occult is often attributed to management; let us hear what ſimple nature ſays on the ſubject of fire. Fire is produced ſpontaneouſly from *vegetables:* hay, for inſtance, formed into a ſtack without being properly dried,—for if properly dried, *i. e.* if totally deprived of water, it would remain ſecure from taking fire. Some water therefore ſeems *neceſſary* to produce fire; but too much prevents it. *Animal* ſubſtances laid on heaps have been obſerved to take fire; M. Montet reports, in the "Hiſtory of the Academy Royal of Sciences, 1776," that ſmall *ſtuffs* called *imperials*, kept in heaps, took fire of themſelves.

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As to an advance toward taking fire, evident by heat, many notorious inſtances occur. The heat occaſioned by fermentation, by putreſcent dunghills, and many other articles, is well known. In general we may obſerve, that more or leſs *moiſture* (*i. e.* water) is neceſſary, and that ſubjects whoſe natural principles are moſt aqueous, are moſt apt to be heated. Paper, which you know, has been linen, and undergone many viciſſitudes, yet when well wetted and laid together in a heap, it will become exceeding hot, ſo that, as my copperplate printer tells me, he can hardly bear his hand on it. As to *mineral* ſubſtances, many of them may be ſaid to be greatly compoſed of fire; give them but acceſs of water, and we ſhall preſently behold a conflagration; of this we have many inſtances.

" Mr. Lemery, as far as I have been able to learn, was the firſt perſon who illuſtrated, by actual experiment, the origin of ſubterraneous fires. He mixed twenty-five pounds of *powdered ſulphur* with an equal weight of *iron filings*; and having kneaded the mixture together, by means of a little *water*, into the conſiſtence of a paſte, he put it into an iron pot, covered it with a cloth, and buried the whole a foot under ground. In about eight or nine hours time the earth ſwelled, grew warm, and cracked; hot ſulphureous vapours were perceived: a flame which dilated the cracks was obſerved; the ſuperincumbent earth was covered with a yellow and black powder: in ſhort, a ſubterraneous fire, producing a volcano in miniature, was ſpontaneouſly lighted up from the reciprocal actions of ſulphur, iron, and water."

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" It has been obſerved, that large quantities of the materials are not requiſite to make the experiment ſucceed, provided there be a due proportion of water: half a pound of ſteel filings, half a pound of flour of brimſtone, and fourteen ounces of water, will, when well mixed, acquire heat enough to make the maſs take fire."

" We are told by good authority, that one Wilſon at *Ealand* in *Yorkſhire*, about the year 1664, or before, had piled up in a barn many cart loads of the pyrites, or braſs lumps, as they were called by the colliers, [uſually ſeparated from coal,] for ſome ſecret purpoſes of his own: the roof of the barn happening to be bad, the pyrites were wetted by the rain; in this ſtate they began to ſmoke, and preſently *took fire*, and burned like red hot coals."

We have an account, in the Philoſophical Tranſactions for 1693, of a covetous maſter of a copperas work at *Whitſtable* in *Kent*, who, in order to break his neighbour's work, had engroſſed all the Pyrites or copperas-ſtone in the country: he built a ſhed over two or three hundred tons of theſe ſtones, to keep off the rain. In the ſpace, however, of ſix or ſeven months, the maſs (being probably wetted by the moiſture of the atmoſphere, or by the rain, which, notwithſtanding the ſhed, might have fallen upon it) *took fire*, and burned for a week; it quite deſtroyed his ſhed, and diſappointed all his hopes of profit; for the pyrites was in part converted into a ſubſtance like melted metal, and in part it looked like red-hot ſtones: all the ſulphur was conſumed, and the neighbourhood

hood was miſerably afflicted by the noxious exhalation which it ſent forth.

There are ſome ſorts of earth from which allum is made, which abound ſo much with the pyrites, that the proprietors of the works are forced to keep them conſtantly well watered, in order to prevent their taking fire.—But it would be uſeleſs to purſue this ſubject further; we have adduced pooof ſufficient, that nature furniſhes materials, which, under certain circumſtances, may become the occaſion of ſubterraneous fires. The requiſite circumſtances are a proper quantity of the materials, a proper portion of water to moiſten them, and perhaps a communication with the air may be neceſſary. A ſmall quantity of the pyrites is ſufficient to kindle a fire; water is almoſt every where found in ſuch great plenty below the ſurface of the earth, that it conſtitutes one of the greateſt impediments to our ſinking pits to any great depth; and air, if it ſhould be thought abſolutely neceſſary to the ſpontaneous firing of the pyrites, may be conceived either to accompany the water in its dripping, or to deſcend into the innermoſt parts of the earth through the fiſſures which are found upon its ſurface.

Theſe inſtances of ſpontaneous fires ariſing from minerals, naturally remind us of the danger to which we are perpetually expoſed by ſuch combinations and effects. In fact, they often have occurred, veſtiges of fires are every where around us; they often are occurring, and I think I may venture to ſay, they would occur more frequently, were they not *reſtrained*. There ſeems little occaſion to doubt the poſſibility of that general

neral conflagration of which we are forewarned; there are ſo many prediſpoſitions toward it, that mere permiſſion ſeems alone wanting to excite them to action. Some have ſuppoſed that deep in the earth fire has its principal reſidence; that there is the ſeat of this element; which from time to time diſpatches its agents, and burſts open raging volcanos, ſpreading deſtruction over the labours of man, or raiſing iſlands from the bottom of the ocean, and making amends for its ravages, in offering new ſettlements for the reception of inhabitants. Theſe are puny efforts, compared to what this element *can* perform; when the deſtined period arrives: when the dread commiſſion is given, it ſhall burſt the reſtraints which have ſo long controlled it, ſhall awake its fury, and ſhiver this terreſtrial conſtruction into ruin. Regardleſs of this beautiful frame of nature, its majeſty and grandeur, its delicacy and finiſhing, its aſtoniſhing inſtances of wiſdom and power omnipotent, theſe ſhall be waſted with devouring rapidity: who then will regret, that human productions periſh in undiſtinguiſhed deſtruction, that what had been the delights of the ſons of men are conſumed, that their pomp, their pride, their emulation, their magnificence, are all annihilated by devouring FIRE?

LECTURE XIV.

LADIES and GENTLEMEN,

WE have treated on thoſe principles, which, from their combination with, and formation of, all ſenſible objects on this terreſtrial planet, are denominated ELEMENTS, *Air*, *Water*, *Earth*, *Fire*, whoſe influences are extenſive, intimate, and indiſpenſable; we trace them with certainty in their effects, and entertain no doubt of their powers, though many difficulties impede our knowledge of their modes of action, or the ſprings and movements, which, by their means, produce ſuch effects as daily occur around us. It remains now, that we hint a few remarks on other principles not leſs intereſting, though leſs frequently the ſubject of our attention.

We have found reaſon to ſuppoſe, that of the four elements, three were fluids; and indeed fluids, by their mutability, ſeem well adapted for general diſtribution and uſe; as their equilibrium, or ſtate of reſt, is without difficulty diſturbed, their courſe is more eaſily directed, and when the impulſe which actuates them ceaſes, they more readily return to that quieſcent ſtate which is natural to them. It muſt, however, be admitted, that by this very circumſtance they are greatly con-

cealed from our inſpection, and our acquaintance with them is conſequently very much impeded.

Beſide the fluids we have mentioned, I wiſh to introduce a few words on that, which is uſually termed the MAGNETIC *fluid*, becauſe firſt indicated by its connection with the magnet, or loadſtone, though now diſcovered to affect iron and ſteel univerſally, and to abound wherever we have carried our reſearches.

The natural magnet, or loadſtone, is a kind of ore of iron, which has been in all ages famous for attracting pieces of iron from a ſmall diſtance, and by ſuch attraction ſuſtaining proportionate weights of that metal. THALES, amazed at ſo conſtant an effect, thought this ſtone *had a ſoul*. This moſt obvious property of the loadſtone, of itſelf ſufficiently embarraſſing and inexplicable, yet is but the ſign of a power infinitely more aſtoniſhing; in fact, this ſubject is a ſtriking proof that nature has many ſecrets, and that philoſophy, if contented with preſent knowledge, foregoes moſt valuable and intereſting diſcoveries, toward which, perhaps, the previous ſteps are already trodden. About the cloſe of the eleventh, or beginning of the twelfth century, it was obſerved, that when the loadſtone enjoyed free motion (as when ſwimming on a piece of cork in a baſon of water), though its direction might be diſturbed by the moſt rapid whirl, yet it would recover the poſition it had quitted; always pointing its ſame ſide to the North.

Experiment diſcovered, that the qualities of the magnet might be communicated from the natural ore to iron in gene-

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ral; and that when ſmall bars of ſteel (called *needles*) were brought into contact with it, and properly rubbed upon it, they acquired theſe virtues in very conſiderable degrees. This operation was called *touching*; and hence originated the mariner's compaſs; an invention, by which the intercourſe of mankind is inconceivably promoted, which, by giving ſcientific ſupport to courage and ſkill, has done more at a ſtroke toward rendering all nations as one family, than all preceding ages, and all the endeavours of philoſophy or learning could accompliſh. If it is aſked, by what means we ſurround the globe? how we dare venture on unknown coaſts, and how we diſcover our ſituation, wherever placed on the face of the earth? We anſwer theſe, and a thouſand other queſtions of ſimilar import, by a reference to the compaſs. If we ſpeak of immenſe continents diſcovered—it was by the aid of the compaſs; if we mention voyages from pole to pole—they are performed by direction of the compaſs: the life, the ſecurity, the perfection of navigation,—is the compaſs.

When the prodigious utility of the compaſs became generally known, nothing could be more natural, than to enquire on what principle this conſtancy of the needle depended, and whether iron might not be magnetic in other ſtates than as ore. The reſult of ſuch enquiries has been a conviction, that the principle of magnetiſm is very generally diſtributed, and that iron either poſſeſſes or acquires it, long after it has been ſeparated from the mineral, and wrought into houſehold utenſils. Scarce a poker, or pair of tongs, which are not conſtantly in uſe, but which (as in parlours) are ſuffered to remain

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in the ſame ſituation for any time, but what are magnetic: out of every paper of ſewing needles, many are magnetic. This is eaſily proved; for if they be tried, ſome one will be found, which attracts and even raiſes up its neighbour, and ſometimes one ſhall poſſeſs power to raiſe up ſeveral, hanging one after another.

An eaſy experiment acquaints us of the preſence of magnetiſm: place a few needles very gently on the ſurface of a baſon of water (where they will ſwim) and taking a needle, poker, &c. gradually bring one end of it very near the floating needles; a motion will ſoon be diſcovered among them, either of advance or of receſſion, more or leſs conſiderable, according to circumſtances.

Every bar of iron, or every needle, ſo far as it is magnetic, has an abiding inclination to point north and ſouth; and its ends are reſpectively denominated north and ſouth *poles*. Theſe poles poſſeſs an attractive, and a repulſive power: the north pole, for inſtance, draws to itſelf whatever of iron or ſteel is not beyond the limits of its attraction; but if two magnetic needles be *oppoſed* to each other, ſo that the north pole of one, be directed to the north pole of the other, a *repulſe* will enſue, and they will mutually refuſe to become united. This quality is accounted for, by ſuppoſing, that there exiſts in nature a fluid generally diſtributed, which has this peculiar attachment to iron (excluding every other metal in every degree), and which *runs* along the magnetiſed needles, entering at the ſouth pole, and *pouring* off at the north pole; conſequently the oppoſitions of two *pourings-off* (as ſuppoſed above) muſt occaſion a repellent force. This fluid is one of the moſt delicate we

are acquainted with; a weak magnet may be ſtrengthened, if rubbed the *right way* for a conſiderable time, by another as weak as itſelf, and this continued will procure a very ſtrong magnet: whereas, a few *rubbings* drawn the wrong way will totally ſpoil it. A few ſtrokes of a hammer, under certain circumſtances, will ſpoil a magnet, and in ſhort, very trifles greatly affect magnetic needles.

We have in the *Philoſophical Tranſactions*, an account of the *reverſion* of the magnetiſm of a needle, ſo that the north pole in a compaſs on board a veſſel, pointed ſouth, after a thunder ſtorm: to the no ſmall ſurprize of the captain and people on board a ſhip in company, whoſe compaſs remained unaffected; who beheld with wonder their conſort ſteering back to the Weſt Indies, inſtead of continuing her courſe for England. So great an effect is rare; though ſmall errors or variations of the compaſs, from thunder-ſtorms, are not unuſual.

When we ſpeak of *the variation of the compaſs*, we always underſtand a certain regular rotation, which in a ſeries of years performs a revolution; for though we ſay a needle, properly touched, points north, yet this is rarely exactly the caſe, it points a little to the eaſt, or a little to the weſt; its *extremes* of declination are indeed a good deal to the eaſt or to the weſt, exceeding twenty degrees in ſome places; for this variation is attended with theſe circumſtances, (1) It is not the ſame two years together in the ſame place, but gradually maintains its progreſs eaſtward, or weſtward, according to which way it is going; till having reached its extreme, it

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gradually returns. (2.) The degree of variation is not the ſame all over the globe; but in ſome places, in the ſame latitude, varies on the different ſides of an iſland, or iſthmus, &c. (3.) Summer and winter have been thought to have an effect on this variation. (4.) Some perſons think, that a very ſlight variation of this variation takes place, even in the courſe of a day, and that at midnight a needle does not point *preciſely* where it pointed at noon.

The foregoing variation of the needle is always *horizontal*; but the needle has alſo another motion, whereby it ſeems as if its northern pole was heavieſt; ſo that this part of the inſtrument *dips*, as it is called, toward the earth, and the other part requires a counterpoiſe, to preſerve a perfect equilibrium. This dipping varies alſo in various latitudes, and has been the ſubject of much ingenuity, though I believe of little practical advantage.

It would be eaſy to add much that might employ our time, were I to introduce ſuppoſition and hypotheſis; — I ſhall only hint, that ſome have thought the earth itſelf to be either one large magnet, or to contain a magnetic globe looſe within it, whoſe poles varying from thoſe of the earth, occaſion a correſpondent variation in the needle; but perhaps we may equally juſtly imagine, that the magnetic fluid is rather ſuperficial, than deep in the earth, and is either furniſhed by the earth, or circulated over its ſurface, in continual ſtreams and currents, not totally unlike the trade winds, though in a contrary direction. How many other fluids may be circulating around us, we know not: I think there are indications

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of more than are uſually ſuſpected, and perhaps time may diſcover, that their influences are not inconſiderable.

As to the ELECTRIC fluid, I frankly own I am at a loſs under what deſcription to arrange it; whether as diſtinct from others, or whether as a peculiar modification of the element fire, which, brought into a ſmaller compaſs than it naturally occupies, has its cuſtomary effect upon light, and becomes viſible by ſhining. I ſhall juſt remark of it, that its diſtribution is general, that its preſence (as diſcovered by proper inductors) is perpetual, that it ſeems to be in conſtant motion, ſcarce maintaining a ſtate of reſt, for an hour; that all objects have their ſhare of it, that objects affect it from a diſtance, that when objects have too little of it, they attract a quantity from thoſe which have too much, in order to maintain an equality; that it ſeems neceſſary to vitality, that it is capable of being collected in very large quantities, that then it may be made to perform moſt, if not all, the operations of common fire; and that, when collected in quantities beyond human ability, it is capable of irreſiſtible effects; witneſs lightning, earthquakes, &c. How far theſe particulars agree to our idea of elementary fire, I ſubmit to obſervation: only adding, that if it be ſo cloſely allied to one of the elements which enters into our compoſition, there is no occaſion to wonder that, when medically uſed, it ſhould produce ſurpriſing and beneficial effects, ſuch as reſtoring feeling, &c. to limbs ſtruck by the palſy, or other diſorders. On this ſubject, I recollect an inſtance of a young man, who, by bathing when violently heated, loſt his ſpeech;—after many months dumbneſs, while attending ſome electrical experiments, he accidentally received the ſhock of a very highly charged

apparatus, which though it knocked him down, and deprived him of ſenſe for the time, yet being taken care of, he recovered his health, and alſo the next day the uſe of his ſpeech. When he was heated, did the cold water deprive him of that portion of electric fluid neceſſary to perform the functions requiſite to ſpeech; which the apparatus afterwards reſtored?

The fluids we have hitherto noticed, ſeem appropriate to our globe; this ſeems to be their reſidence, their abode; we perceive them by their activity, their effects, their influences; and yet we find reaſon to ſuppoſe, that their nature is rather reſt than activity: what then excites them to motion? Is there one univerſal agent whoſe directions they obey, one prime (mechanical) cauſe which determines their courſe, which impels them to action, by its preſence, which if withdrawn, their action ceaſes? If there be ſuch a general regulator, I think LIGHT ſeems to anſwer to the character; a fluid immenſely minute in its parts, aſtoniſhingly rapid in its progreſs, and of powers beyond comprehenſion: ſome of its properties we ſhall conſider, as they appear to us; whether they will prove its univerſal agency, I do not determine.

We had occaſion in our laſt diſcourſe, to ſuggeſt various opinions which have been maintained in relation to the element fire; which by moſt philoſophers has been (as appears to me, too much) confounded with light: one of theſe opinions ſuppoſed, that light was merely a particular motion propagated by vibrations, or ſhocks, through a ſubtle æther. This idea had at one time many voices in its favour, and its ſimilarity to the principles of ſound ſeemed much to

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recommend it; but the properties of light with reſpect to colours, to inflection, and refraction, ſeem clearly to evince its being rather a material ſubſtance emitted from luminaries, and paſſing tranſparent mediums, but repelled by opake bodies.

We ſhall regard the ſun as the ſource and principle of our light; perpetually diſtributing from its ſurface millions of particles extremely ſmall, extremely elaſtic, and extremely rapid in their motion.

The particles of light are extremely *ſmall*: to prove this, I ſhall not have recourſe to calculation, or tell you they are leſs than *the twelve millionth part of a grain*, becauſe the mind finds no leſs difficulty in conceiving ſuch minuteneſs, than if abſtract terms were employed; but I ſhall aſſume, that we ſee objects only by the light they reflect to our eyes. Let us fix this well in our minds; the rays of light rebounding from objects, enter our eyes, and theſe inform us of the preſence of thoſe objects, their forms, their colours, magnitudes, &c. Let us inſtance this: I, in this room, behold my notes, the table before me, the candles, &c. upon it, the company around it, conſiſting of a multitude of particulars on either hand, of a multitude of various colours and forms in very diverſified combinations; and beyond the company, I diſcern the very prints and drawings which ornament the apartment. All this I perceive at one ſingle glance; that is to ſay, rays from every one of theſe objects, their diviſions, and ſubdiviſions, enter without confuſion into ſo ſmall an aperture as the pupil of my eye: that I might diſtinguiſh the writing before me, is ſuppoſable; but that I ſhould equally well

diſcern every fold in a dreſs, every ſtripe of a ribbon, and the very colours and forms of the figures in a drawing on the wainſcot, implies wonderful fineneſs of the rays, which theſe minute objects tranſmit to me. If, in the day time, we advance to the window, we receive rays from innumerable objects; we look down a long ſtreet, we ſurvey every houſe, every paſſenger, and we read the very figures on the church clock at a diſtance.

Let us ſuppoſe ourſelves on ſome lofty mountain's brow; around us below are fruitful meadows, wherein we diſtinguiſh every tree and coppice, every houſe, almoſt every tile; we ſee the labourers at work, we ſee the courſe of a river, the country beyond it, miles after miles, till the ſea cloſes the view, and juſt upon the horizon up pops the maſt of a veſſel, with a flag upon it; theſe we diſtinguiſh with the naked eye: now apply to a teleſcope; we not only ſee the ſame things much ſtronger, but we alſo ſee many parts which are too ſmall to permit diſtinct viſion to the unaſſiſted eye; but we view them through the glaſs, we ſee the form of the flag, and even the croſs upon it: from this croſs then iſſue rays of light, and theſe rays reach the glaſs, elſe we ſhould not ſee the object. Combine, if you pleaſe, theſe particulars; you cannot but acknowledge the very amazing minuteneſs of thoſe rays, which are able to paint all this in the dimenſions of a quarter of an inch, or leſs; what then will you ſay, when I refer you to the moon, and tell you rays from an object two thouſand miles in diameter enter your eye without confuſion; or to the ſun, reminding you it is millions in dimenſions; or

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to the heavens, which are inexpreſſibly extended, yet from their ſtellar fires—above—to the right—to the left, what prodigious ſtreams of light reach, enter, and are tranſmitted through the eye! After this, I think we may juſtly forego any meaſurement of the particles of light, either by dimenſions, or by weight; and yet I doubt not they have both; and both have perhaps very ſenſible effects upon us; they *wear out* our eyes. The light which falls perpetually on our eyes, in a courſe of years, perhaps abrades the retina, or corrodes it, even ſuppoſing they are not particularly expoſed to its effects; but in ſome buſineſſes which require very ſtrong light, it is not uncommon to find their profeſſors very early in life complain of dimneſs of ſight.

I ſaid alſo, that light is very *elaſtic*; that being thrown againſt any object, it rebounds like a ball from a wall, but with infinitely greater velocity: Only attend to what we have been ſuggeſting; whence come the rays which, when we are on a mountain's brow, ſhew us the trees, the coppice, the dwellings below? Whence come the rays which the diſtances direct to us? or thoſe which render viſible the veſſel's maſt, and its flag? From the ſun: the ſun ſends them to the earth with vigour; and from whatever they ſtrike, they rebound to a very great diſtance.

I remember to have heard of a lady's obſervation, who ſtanding on the White Tower in London, through a teleſcope could diſcern the ſparkling of a pair of diamond buckles, worn, at that time, in Greenwich park: that is to ſay, the ſolar beams which fell upon the diamonds, though refracted by

by them, and turned out of their courſe, yet were ſufficiently elaſtic to rebound, ſo as to be ſenſible, through a glaſs, at three or four miles diſtance. How much further they might reach, is difficult to ſay. Is this ſurpriſing? Let me remind you, that the gliſten of windows from a houſe on a hill, in an evening, may be ſeen much farther; and what is this gliſten? a very ſmall portion of light; for by far the greater part paſſes *through* the windows into the rooms of the houſe, which it fills. Nobody in the rooms perceives any deficiency of light, but that trifling quantity which happens to be repulſed from the ſurface of the glaſs, ſpreads all around, and becomes viſible to the eye even in ſtrong day-light, at many miles diſtance. How far does it travel ere its progreſs be totally ſubſided? Be it remembered, that when the eye does not perceive it, a teleſcope will diſcover it, and a very powerful teleſcope will notice it at an amazing diſtance. In fact, we may conceive, that a very great number of rays, thus reflected from equally ſmall points, enable us to ſee the moon, and the planets: the ſatellites of Jupiter are indeed too remote to be ſeen by the naked eye, yet we are ſure they ſend us light; elſe how could a teleſcope render them viſible? The ſame we aſſert of thoſe which ſurround Saturn, which are viſible only by powerful glaſſes, in a tranquil ſtate of the air. I ſay, the light from the ſun ſtrikes them with velocity ſufficient to rebound by its elaſticity from them to us; the extent of the diſtance you know. Need I ſay more? need I appeal to the Georgian planet, to its ſatellites, at twenty times the diſtance of the ſun from us? I rather think I may conſider the

aſſertion

aſſertion as demonſtrated, and conclude that light is extremely elaſtic.

The *rapidity* and *velocity* of light ſeems, I think, to follow from what has been hinted; it is inconceivable that a ſlow-moving, heavy ſubſtance ſhould be thus elaſtic; or that a particle, ſo very minute, ſhould *ſleep* in its paſſage. On the contrary, a particle, an atom, thrown from a body ſo vaſt in bulk as the Sun, muſt needs quit that body with alacrity; when, by the rotatory motion of the Sun, its time is come to be whirled away, ſcarce the ſwiftneſs of thought can equal its rapidity.

You know that the firſt demonſtration of the paſſage of Light was gathered from eclipſes of Jupiter's Satellites, after which proof many others were diſcovered. That which is uſually conſidered as moſt ſurpriſing, is what has been obſerved of the fixed ſtars, whoſe light is calculated to take up *ſix years* in coming to us, and yet is *ten thouſand two hundred and ten times* ſwifter than the velocity of the earth in her orbit; and equal to *one hundred and ſeventy thouſand miles* in one ſecond of time. Is it not by this time apparent, that it is well for us light is ſo very ſmall in its particles? for were it only one millionth part of a grain in weight, what miſchief would it not occaſion! wherever it fell, it would ſtrike with at leaſt the force of a grain weight falling an hundred yards, which, on the tender coats of the eye, would be injurious; but what ſhall we ſay to this injury perpetually repeated?

Light always proceeds in one direction; *i. e.* a right line from the luminary which emits it: this is eaſily proved by ſhadows, which are ſo many interceptions of light, whoſe

forms always correſpond to thoſe of their original, and to lines drawn direct from the luminary. But though light naturally proceeds in ſtrait lines, it is very ſuſceptible of the attraction, as well of denſer mediums, as of ſolid bodies. We have heretofore noticed the power of the atmoſphere, in attracting and bending rays of light, which we obſerved continually increaſe their inflection the nearer they approach the earth, becauſe the medium is continually increaſing in denſity. This is conſidered as evidence that light is truly matter; ſince all matter is attracted by other matter, and feels its influence.

As a proof; we find by experience, that in proportion to the denſity of a body is its effect upon light; hence the refracting angle of water differs from that of glaſs, and particular glaſſes differ from each other. There is no neceſſity for recurring to mathematical calculation in demonſtrating theſe principles (though mathematics inform us more accurately of their powers and limits); whoever will hold a glaſs goblet, full of hot water, between his eye and a lighted candle, will ſee that the riſing vapour has an effect to move the apparent ſituation of the light a little from its true place; then let him elevate the goblet, till he looks through the water at the light, which will be conſiderably diſplaced; then emptying the goblet, look at the light through the glaſs, raiſe it, lower it, move it on one ſide, then on the other; look through its ſolid ſtem; and it will appear, that the glaſs draws the rays of light ſo powerfully out of their courſe, that the real luminary, and that apparent in the glaſs, may be both ſeen at once,

ſome

ſome inches diſtant from each other. Were any much denſer tranſparent medium equally familiar, theſe principles would receive additional ſupport.

Light is by ſome bodies received, and admitted, indeed; but ſo ſuperficially and circuitouſly, that it becomes ſtifled, blunted and deadened: whereas other bodies permit it to paſs directly through them, and theſe are tranſparent while the former are opake. We may conſider bodies in reference to this idea, as compoſed (1.) of ſimilar and homogeneous particles, making one uniform medium of equal denſity throughout (ſuch are water, glaſs, and diamonds), poſſeſſing equable diſpoſition of particles, and of pores: light paſſes readily through theſe, becauſe it ſuffers only one inflexion, in proportion to the denſity of the medium; to which having accommodated itſelf, it purſues the ſame courſe *through* the medium; which is thereby tranſparent. (2.) But if a body be compoſed of various diſſimilar and heterogeneous particles, ſuch as metallic *laminæ*, ſalts, earths, oils, water, &c. theſe being different in denſity, in diſpoſition, in pores, &c. light is ſo twiſted, twirled, and haraſſed in endeavouring to find a paſſage, that it is totally loſt and abſorbed; and does not paſs through the body. Opacity then proceeds from the windings of light, and the ſinuoſity and meandrings of the pores of bodies, and from the irregular ſituation of their particles. Oil and water mixed are opake, though tranſparent ſeparately. Beer is tranſparent, but its bubbles are opake. Dry paper is opake; wet paper is tranſparent, becauſe the water interpoſed between the particles of the paper fills its

pores,

pores, and affords more direct paſſage to the rays of light. The moſt opake bodies, as wood or marble, are tranſparent when thin, becauſe they do not poſſeſs a ſufficient number of diſorderly pores, to prevent the light paſſing in tolerable regularity. But the moſt tranſparent bodies (as glaſſes) do not tranſmit *all* the light which falls upon them, but a conſiderable loſs of light happens, by reaſon of what *ſprings back* upon its ſtriking the glaſs; and this is found an inſuperable difficulty in conſtructing teleſcopes, which, requiring ſeveral magnifying glaſſes, loſe a portion of light from each, till at length, if too many glaſſes be interpoſed, there ſcarce remains light enough to depict on the eye the objects viewed, but a kind of white cloud ſeems to veil them.

We have proved that the particles of light are extremely ſmall; we have now to add, that they are nevertheleſs thought to be of different ſizes; our reaſon for thinking ſo is, they are found to be of different colours, for colours are certainly the offspring of light, and every ray of the ſun being a *mixture* or union of ſeveral kinds of light, excites in our eyes ſenſations correſpondent to the component parts of ſuch mixture. You muſt needs have obſerved the various highly brilliant colours which ſucceed each other in a bubble blown from ſoap; they appear as ſo many real colours, but are undoubtedly ſeparations of the rays of light which fall upon the bubble, into their primary principles. We obſerve the ſame colours in cut glaſſes of all kinds; alſo very evidently in drinking-glaſſes, when filled with water; ſee what colours they caſt on a table-cloth; ſee what colours appear in the

ſtems

ſtems of ſuch glaſſes, in the light tranſmitted through their feet, &c.

To the ladies I further ſuggeſt the inſtance of *paſte* pins, or buckles, mother of pearl, and ſeveral kinds of gems, though leſs familiar; what renders them ſo brilliant? why do they exhibit ſuch variety of beautiful colours? different in different ſtones of the ſame buckle: and why is the colour changed by the leaſt motion? a proof the ſtone itſelf is of no particular colour. The anſwer is ready—the rays of light which fall on ſuch a buckle, &c. are, by the refractive power of the paſte, divided into their ſeveral original colours, which making different angles of refraction, exhibit that particular colour which correſponds to the angle at which the eye views it. The ſame principles account for the highly reſplendent colours of the varying plumage in the necks of many birds.

The uſual proof of this poſition, is the ſeparation of the rays in a glaſs priſm; and this, becauſe eaſily manageable, is now familiar. We have nothing more to do, than to ſhut out all light from a room, except what is admitted through a ſmall hole in a window-ſhutter; againſt this hole place a glaſs priſm, and let the rays which paſs through it fall on a ſheet of white paper at a convenient diſtance. We obſerve, that the image on the paper will not repreſent a hole of correſponding ſhape, but will be very much lengthened, and will contain various colours, in the following order: red, orange, yellow, green, blue, indigo, violet, or a kind of blackiſh purple. Theſe are termed the ſeven *primary* colours;

and

and of theſe all others are compoſed. Theſe colours appear always in the ſame order, and never with various intervals. Here, then, we have a ray of light which we uſually call *white*, ſeparated into ſeven other colours, none of them being white.

It is natural to aſk, can we recombine them into whiteneſs again? We anſwer, Yes; by uſing a proper lens to counteract the effects of the priſm, we return the rays from their preſent ſituation, and conduct them to that ſpot where they would have fallen, had no priſm intercepted them: here, re-united, they become white. If you aſk, whether they will not be whiter if the red ray be omitted? we anſwer, No: the predominance of the blue will prevent it: If the blue be omitted? No; the red will ſtrongly glare; the whole is neceſſary to produce perfect whiteneſs, and no improvement can be made, by addition or diminution. Neither is it poſſible to change the colour of one of theſe ſeparated rays; for inſtance, the red rays, tranſmitted through green glaſs, will receive no tinge of green, but will on a white paper ſtill depict a red; or the blue ray, tranſmitted through a red glaſs, will ſtill continue blue.

Is it inquired, *why* the glaſs ſeparates them? (which returns to a queſtion already hinted) we can give no other reaſon, than ſuppoſing theſe rays to conſiſt of particles of various ſizes, which are proportionately attracted by the glaſs: the ſmalleſt particle is moſt ſtrongly attracted; we therefore expect *that* to paſs out of the glaſs at the *greateſt* deviation from its natural courſe; this anſwers to the *violet* colour; or,

particles of light of this ſize, affect our ſight with a ſenſation which we expreſs by the term *violet colour*. If we ſuppoſe a number of particles ſomewhat larger, they will leſs feel the attractive influence of the glaſs, and will be leſs diverged; theſe ſhall be, if you pleaſe, the *yellow*: and another ſize yet larger, ſhall be the *red*. Red rays then will always be the neareſt to their natural direction, and may be thought the ſtrongeſt colour, while the weaker violet ſuffers moſt violence, and is moſt deflected from its courſe.

Perhaps this matter may be yet more ſimply ſtated, thus: light conſiſts of three kinds of rays, red, yellow, and blue (for the intermediate colours are mixtures), which either iſſue in union from the ſun, or are ſo united in their paſſage to us, as to form but one fluid when they arrive here; this fluid contains, therefore, the principles of all colours, and is ſeparable into all colours, if bodies properly adapted to reflect its various modifications and mixtures be ſubmitted to it. Black is the privation of colour; we are not therefore to expect this as reſulting from light. White is the union of all the primary colours, and the more complete their union, the more brilliant the white.

What ſay natural objects to this theory? Obſerve the clouds; they refract, and reflect the ſun's light; obſerve in an evening, how their colours gradually change from the afternoon's whiteneſs to deep crimſon, and how that gradually changes to violet, and to grey. Obſerve the atmoſphere when the ſun ſets without a cloud; when he is ſomewhat declined, examine that quarter of the heavens oppoſite to him, it is

red; and here it fades to violet. Around the ſun is yellow, over head is blue; trace the progreſs of theſe colours where the ſun ſets; from red to orange, to yellow, to *greeniſh* (this is uſually but faint), to blue and to grey. The gradual introduction and ſucceſſion of theſe colours at different angles from the ſetting ſun, are not only pleaſant to obſerve, but alſo demonſtrate that theſe principles are founded in nature.

But, the grand natural proof of theſe principles is the RAINBOW; which is ſimply a various application of them on an enlarged ſcale. I ſhall advert again to the paſte buckles; we ſaid, that according to the angle of the beholder's eye, with regard to any one of theſe ſtones, ſuch would be the colour viſible to him. We ſuppoſe then, a ſtone at a certain angle ſhews red, elevate this a little it ſhews orange, a little higher it ſhews yellow, then green, blue, and ſo on, at different elevations. Inſtead of theſe different elevations of one ſtone, ſuppoſe each colour were allotted a ſtone to itſelf; then have we the primary colours of the bow. We have only to change theſe ſuppoſed ſtones for real drops of water, and the ſame effect will be produced. Whenever the ſun's light ſtrikes upon falling drops of rain, it is by them refracted into the priſmatic colours; and if a ſpectator be placed in a proper angle to view them, theſe refractions will indicate themſelves by ſhewing various colours to his eye. The angle under which the *moſt* refrangible rays are ſeen, is 40 deg. 17 min. the angle under which the *leaſt* refrangible rays are ſeen, is 42 deg. 2 min. and all the particles of water *within* thoſe two angles will exhibit the priſmatic colours, and conſtitute the

interior

interior bow. To account for the circular form of the bow, we have only to reflect, that this angle is permanent; and as, well on either hand, as looking upwards, requires the ſame degrees: if, therefore, it maintain an equal angle on all ſides, the *ſweep* of this angle (and of the bow) muſt be circular. The bottom part of the bow follows the ſame law; and rain-bows, *completely* circles, were ſeen by thoſe who, on the top of very highly elevated mountains, could ſee to the angle requiſite, as well below as above: as was the fact with thoſe gentlemen ſent by the kings of France and Spain, to meaſure an equatorial degree. The ſight muſt have been extremely curious; and yet, among ſuch danger and difficulties, no one will envy it. When, however, without danger and difficulty, nature preſents what is curious to the eye of obſervation, it inſpires a pleaſure of which ignorance is incapable. I ſhall frankly own, that at my laſt trip to Ramſgate, I was highly delighted with what is termed a SEA-BOW, *i. e.* the priſmatic colours refracted from the ſpray of the waves of the ſea. To produce this, the ſea muſt run high enough to afford a good deal of daſhing ſpray; and the ſun muſt (as in a rain-bow) be behind the ſpectator. But as it ſeldom happens, that when the ſea runs ſo high the ſun ſhines out clear and free from clouds, theſe phenomena are rarely noticed. The principles of this bow are the ſame as thoſe of the rain-bow; but as many bows are ſeen at once, each wave making one, the ſight is extremely curious. I remarked of one formed by the ſpray ſo cloſe as to ſprinkle me (I do not

grudge

grudge a ſprinkling for the ſight), that its colours were highly brilliant and lively, very ſparkling, though momentary.

To account for the appearance of a kind of *ſecond Rainbow above* the firſt, of fainter appearance, and whoſe colours are *reverſe* from the former, I ſhall remark, that though much of the light which falls upon a drop of rain be refracted and reflected, and paſſing to the ſpectator's eye, there exhibit the priſmatic colours, yet other rays remain which, after being reflected are again refracted, and quitting the drop at another part, *there alſo* diverge into the primary colours; ſo that were a ſpectator properly placed with regard to theſe, they would to his eye depict a coloured bow. This double effect cannot be produced by the ſame drops to the ſame ſpectator, but proceeds from different ranges of drops at different elevations. It is natural to infer that the colours of thoſe rays which have ſuffered moſt refractions will be weakeſt.

As to *Lunar Rainbows*, they follow the ſame principles; and differ only as being occaſioned by weaker light, being ſeen in the night time, and by being pale, or perhaps exhibiting one or two colours only *well*, the others imperfectly.

In the foregoing obſervations the ſpectator has always been ſuppoſed *between* the luminary and the cloud; but when a cloud is between the ſpectator and the luminary, what follows? If the cloud be ſo conſiderable as to preclude the paſſage of light, it is clear none of the effects of light can be expected; but if it be thin, light, and tranſparent, we look for a HALO, or circle tinged with colours, ſurrounding the luminary. Theſe are uſually ſeen at night, and are thought to be light refracted through the ſides of congelations

lations ſomewhat flattiſh in form, wherein the red predominates as the leaſt refrangible colour, and the extremities have a tint of blue. Sometimes we ſee round the moon only a circle of white, commonly very large; this is always in hazy weather, and originates from light reflected by ſuch vapours; being larger or ſmaller, as they are more or leſs elevated. Vapour confined in a glaſs goblet when juſt forming drops, before it begins to run down the ſides of the glaſs, if placed before a light, and looked through, will exhibit the rudiments of a halo. The infinity of combinations among the clouds in the atmoſphere, prevent the frequency of theſe phenomena. The rays of light are alſo promiſcuouſly blended, and do not emerge parallel from drops in ſuch clouds to the ſpectator's eye; if they did, we ſhould ſee round the ſun, through a raining cloud, much brighter rainbows than we now are acquainted with.

If light be a fluid ſo exceedingly minute, and ſo ſtrongly affected by all ſenſible objects, ſtriking here, rebounding there, iſſuing from all quarters, and never reſting, no wonder it viſits every creek and corner. If we forbid it when direct, it will enter by reflection, from ſome obliquity, from ſome object, near or remote; and while this fluid and its effects are ſo neceſſary to human comfort, let us ever remember with gratitude this its important property. Cuſtom has rendered a great quantity of light neceſſary, to us who enjoy it at liberty; but it has been found by thoſe in cloſe confinement, that a little light enables them to diſcern even diminutive objects. I remember hearing the ſtory of a man, long impriſoned in the dungeon of the Chatelet, at Paris, whoſe eyes

became

became gradually ſo habituated to his darkſome abode, that he could ſee the rats and mice which ran around him to pick up his crumbs. We may therefore juſtly ſuſpect, that we are never *totally* without light, even in the darkeſt night, or the moſt profound obſcurity: perhaps as the earth imbibes and treaſures up heat, ſo it may light in ſome degree at leaſt.

There are ſundry other effects produced around us by the agency of light, which occur to obſervation; they chiefly reſpect its colorific operation. Plants excluded from light loſe their colours, and become of a dingy white; but if any opening be left whereat light may enter, they will uniformly incline towards it, and thoſe leaves which neareſt approach it will be green, while thoſe at a diſtance are white. Plants, while ſprouting, being concealed from the light by a covering of earth, are white; but no ſooner do the tender leaves appear above ground, than they become green. Light, therefore, or its effects, ſeems neceſſary to the maturity of plants; or at leaſt to that of their colours. Certain apples are painted from green to red, by frequently drawing upon them (when on the tree) by a pencil of water, the figure propoſed, the pencilled parts gradually become red. Painted pictures, precluded from light, fade and become tarniſhed. If the ſouth aſpect of a houſe be painted, it will keep its colour better than the north aſpect; and very much better than an underground apartment having a north aſpect.

Light is found under certain circumſtances to have corroſive effects; but there ſeems to be much caution required in determining what effects are attributable to light itſelf, and

what

what to other agents, whoſe activity it impels; and while light and fire have been ſo generally confounded, no wonder the performances of one have been attributed to the other; or effects, in which perhaps both are neceſſary, have been thought to be produced by one alone. It ſeems, that the lunar rays (which are certainly mere light) have the effect to putrefy fiſh; or at leaſt very greatly to haſten their putrefaction; and therefore, in ſouthern climates, the fiſhermen very carefully hide their fiſh from the moon-ſhine, a few hours expoſure to which would render them unſaleable.

It is very probable, that many other effects ariſe from this active fluid: but we are compelled to recollect, that our acquaintance with it is of neceſſity imperfect. Sight is the only ſenſe which determines of its preſence, and ſight has the reputation of being eaſily deceived. Take a ſpecimen or two. The rainbow, ſays ſight, exiſts in the cloud: No, ſays philoſophy, the falling drops of the cloud only ſeparate the rays of light, and theſe ſeparated rays *appear* to you in the form of a bow. A candle in the dark has a ſplendid crown of rays attending it: No, they exiſt only in your apprehenſion, being produced by the impulſe of light on the Retina. Stars twinkle: No, they are alternately hid and diſcovered by atoms floating in our atmoſphere. In fact, it has been queried, Whether there be any ſuch quality as colour really exiſting; whether the rays of light, ſeparate or combined, direct or reflected from ſurfaces proper to ſuch or ſuch rays, do not merely excite in our minds, by peculiar effects on our ſight, *Ideas* of correſpondent colours; inſomuch, that it may be

ſaid, the ſeat of colours is rather the eye as it affects the mind, than coloured light, or than coloured objects?

It is not eaſy to reaſon accurately, yet familiarly, on mental perceptions; nor is it always that analogy muſt be truſted as a guide; yet when it affords an opening, we accept with pleaſure the labours of thoſe who endeavour to trace it. The agency of light we have noticed in various inſtances: ſhall I be permitted to ſuggeſt, that its influences are yet more extenſive. I trace them thus, light is the fineſt and moſt powerful of fluids, impelling the fire by the agency of the ſolar rays; the fire expands and agitates the air, hence the origin of winds, the elevation of vapours, &c. Fire alſo affects the waters, maintaining them in fluidity, &c. Air, actuated by fire, affects the waters in the inſtances of ſtorms, vapours, &c. Water, air and fire, as excited by light, affect the earth, by imparting the principles of fertility:—it ſeems, therefore, as if we might ſafely conſider light as the firſt cauſe, acting through various elementary mediums. Or ſtate it thus: life is ſupported by the productions of the earth;—which productions are compoſed of earth, water, and air, each of which has been excited by fire, and fire is excited by light. All the four elements are neceſſary to maintain life; but they muſt have action communicated to them, for of themſelves they are inert. They are all likewiſe neceſſary; take away earth, of what value were the impulſes of air, water, and fire, without a ſubject? Take away water, what an arid deſart were the whole globe? Take away air, how ſhall we breathe? Take away fire, behold a frozen world, a globe of ice! Take

away,

away their chief agent, behold darkneſs that may be felt; the fire ceaſes its office, air, water, earth, are equally conſolidated, equally hardened, equally unfit for the ſupport of inhabitants; the reſidence of horror and deſpair, brooding calamities, deſolations, and woes.

When we advance beyond the boundaries of our habitation, we muſt modeſtly content ourſelves with conjecture; aſſertion ſhould only follow demonſtration,—and demonſtration is commonly the reſult of multiplied inveſtigations: without attempting which, I ſhall ſuggeſt a few hints which ſeem to me well founded. I think there can be no continued motion of any body, unleſs there be a continued impulſe upon it: If we ſuppoſe any intermiſſion, the motion will ceaſe. Likewiſe, that though a very large body requires proportionate impulſe, yet if in itſelf it be quieſcent, and the impulſe upon it be all in the ſame direction, and there be no contradictory impulſe from any quarter whatever, an agent apparently feeble may have great effects. Let us apply theſe ideas to the motion of the earth as a planet, by ſuppoſing that an unceaſing flood of light circulates round the ſun, carrying with it whatever it meets in its courſe. Does not light then quit the ſun in ſtraight lines, thereby driving a body *from* the ſun? Perhaps not: not *perfectly* ſtraight. I reaſon thus: the revolutory motion of the ſun about his axis, ſeems deſigned to throw off his ſuperficial particles of light; no particle thrown from a revolving body follows a perfectly ſtraight courſe, witneſs the drops thrown from a mop when trundling ('tis a familiar compariſon though a homely one), witneſs

neſs the drops from a water-wheel, and many other inſtances. We may then aſſume, that the particles of light from the ſun fall ſomewhat *obliquely* on the planets: next we enquire, which way do the planets circulate? The anſwer is, The ſame way as the ſun revolves; *i. e. coincident* with this ſuppoſed courſe of the rays of light; the planets and the light follow the ſame courſe. But ſome planets have others around them; what impels theſe? Reflected light from their primaries: the moon revolves round the earth in the ſame direction, as that of the light reflected from the earth, conſidered as a rotatory body. Perhaps, even the daily rotatory motion of the earth is maintained by light; and perhaps the reaſon of the ſo ſlow rotation of the moon on her axis, is, the contradictory direction of the rays ſhe receives from the earth, with regard to thoſe ſhe receives from the ſun: if this cauſe were abſent, the length of her days and nights might be ſhortened.

I beg to have it underſtood (1.) that I merely throw out theſe remarks as hints; though I own I think them plauſible. (2.) That I do not think light acts in contradiction to gravity and attraction (much leſs do I think it acts without them), but in conjunction with them. (3.) That I do not think light, or any other mechanical principle whatever, originally imparted this motion; but, that it *may* be the agent made uſe of by the Supreme Intelligence, to *maintain* thoſe motions which his power and pleaſure communicated. (4.) That the motions of comets ſeem to have a relation, in certain reſpects, to laws different from thoſe which regulate the planets: and I am not endeavouring to account for cometary motion.

We

We have ſuggeſted our ideas on the motions of the earth and moon, let us beſtow a moment's attention on the other planets. (1.) All the planets move the ſame way: *i. e. coincident* with the *declination* of the ſolar rays. (2.) All their moons move the ſame way: *i. e. coincident* with reflected light from their revolving primaries. When any ſecondary planet ſhall be diſcovered moving *contrary* to this principle, the whole hypotheſis muſt be abandoned. (3.) The neareſt planets to the ſun receive his light, while it has moſt force; they therefore circulate quicker, as well by that cauſe, as becauſe they have leaſt ſpace to paſs through. (4.) I ſhould not be ſurpriſed (or at leaſt I do not think it impoſſible) if gentlemen verſed in calculation ſhould turn their thoughts this way, if they ſhould diſcover the proportionate impulſe of light, by conſidering the proportionate diſtances of the planets, their periods, and thoſe of their ſatellites, in conjunction with the velocity of light, which no doubt leſſens, according to ſome regular law, as its diſtance from the luminary encreaſes.

It is clear, that by this train of reaſoning, a vacuum is totally exploded throughout the ſolar ſyſtem, for we ſuppoſe the progreſs of light to be inceſſant. I think too, it is exploded from every part of the univerſe with which we are acquainted: for where ſhall we place a ſpectator beyond the reach of light? Were our own ſun withdrawn (as at night to us he may be ſaid to be), ſtreams of light from the ſtars are multiplied around us; and where is their light inviſible? In which direction ſhall we fly to avoid it? to the right? we

advance

advance toward ſome of theſe reſplendent bodies; to the left! we advance toward others; from each of which iſſue, in every direction, ſtreams of light. It is true their united beams are too feeble to anſwer the purpoſes of human life; their *comparative* effect is ſmall; and therefore the ſun is appointed as neceſſary for our uſe. This is the dignity, the glory of light, it is indiſpenſable: to us! not to us only; throughout the univerſe. Wherever are creatures there muſt be light, if they may be comfortable; and if by their ſituations they be too remote from other ſources of light, behold ſuns created to furniſh light for their uſe. Hence our ſun ſhines on us by day, hence our moon reflects his beams by night; hence remoter planets have many attendants; hence ſtars are diſtributed throughout the vaſt expanſe. Are there exiſtent beings? There is a luminary. The firmament is crowded with luminaries, becauſe light is of univerſal enjoyment. This they beſtow, this they circulate, and (probably) this they re-collect. Light maintains the intercourſe between diſtant ſyſtems, flies inceſſant throughout ſpace, diffuſes numberleſs bleſſings in its progreſs; ever alert, prompt, vigorous, is not this the univerſal agent, that, without which, to be were not being!

This ſeems a proper ſtation at which to pauſe for a moment, and to ſolicit your attention, LADIES and GENTLEMEN, to a retroſpect of the ſubjects we have lately diſcuſſed. What prodigious exertion of contrivance and wiſdom is employed to render this our dwelling ſuitable for inhabitants! *fitted up* for

our reſidence at an amazing expence of power and ſkill; at once beneficial and elegant; replete with the neceſſaries and pleaſures of life; and offering for ſupport or delight, all that we are capable of enjoying, all that is adapted to our nature, all that may ſatisfy our wiſhes.

What wiſe œconomy appears in the compoſition and diſtribution of that neceſſary element AIR! to which we are under ſo many obligations, as ſupporting life by reſpiration, as friendly *tempering* our circulating blood, as contributing to our enjoyments of ſeeing and of hearing, and indeed of all our ſenſes. While vegetation is influenced by Air, and the ſupports of life are themſelves ſupported by it, to deny that we are beholden to this element, were not only ingratitude, but madneſs.

Nor let the cooling beverage, the tranſlucent ſtream, whether murmuring in the humble water-courſe, or rolling in the magnificent river, let it not paſs without our acknowledgments. With what heavier curſe could a man curſe his enemies, than to wiſh them deprived of this ſalutary principle? Over head—a burning ſky; beneath the feet—a parched ſand; around—a wide ſpread deſart; no ſhrub to relieve the weary eye, no verdure to vary the tireſome proſpect, to ſuggeſt the *poſſibility* of refreſhment; ſuch is the aſpect of a land without WATER! forſaken of vegetables, forſaken of animals, wild, barren, dreary, deſolate. O for a bubbling fountain, for a cool ſpring, whoſe ſalubrious draught may reſtore enervated vigour, and call back departing life! Fountains and ſprings Nature offers in plenty, freely diſtributing this indiſpenſable

element, at once abundant and invaluable; ſuch is her liberality to the ſons of men!

On the productions of EARTH we ſubſiſt; we ourſelves are among its productions; and however endowed with reaſon or genius, with acuteneſs of thought, or depth of underſtanding, we trace our origin from the duſt, and acknowledge our compoſition is but clay. A reflection at once exalting and humiliating. Of *this* Earth is capable! Is this capacity attached *to earth?* has *earth* been animated, enlivened, ennobled, in the rank of Being? Is this nobility, this life, this animation, combined merely with *earth!* which ſhall ſoon return to its firſt principles, to its native inſenſibility: how amazing is this!

Equally neceſſary the ſervices of FIRE, equally numerous, equally valuable, whoſe principles, indeed, are concealed in obſcurity; from whom we receive many, many benefits, yet whoſe mode of action defies our ſtricteſt ſcrutiny, our acuteſt penetration; ſecluded from detection by danger, and eſcaping from acquaintance by tenuity.

Hail, holy LIGHT, offspring of heaven! firſt born,
Or of th' Eternal co-eternal beam!
May we expreſs thee unblamed? ſince GOD is light,
And never but in unapproached light
Dwelt from eternity; dwelt then in thee,
Bright effluence of bright eſſence increate!
Whoſe fountain who ſhall tell? before the ſun,
Before the heavens thou wert——

After theſe noble lines, what *can I* add? 'tis little to repeat

the

the properties of light as known by mortals, little to ſuggeſt the ſervices of light as received by mortals, little to ſurvey the extent of light as comprehended by mortals, yet this is *all* which *I can* do. Summon your own powers LADIES and GENTLEMEN, trace this bright fluid through diſtant realms, accompany it to other ſpheres, preſs on wherever it extends, follow to its termination, diſcover its boundaries, examine its limits, and only ceaſe where it ceaſes; is this too much, too much for the powers and capacities of mortals? let us glory in the idea of what hereafter we may accompliſh, and at preſent join the poet's prayer,

So much the rather, thou CELESTIAL LIGHT,
Shine inward, and the mind through all her pow'rs
Irradiate; there plant eyes, all miſt from thence
Purge and diſperſe, that we may ſee and tell
Of things inviſible to mortal ſight.

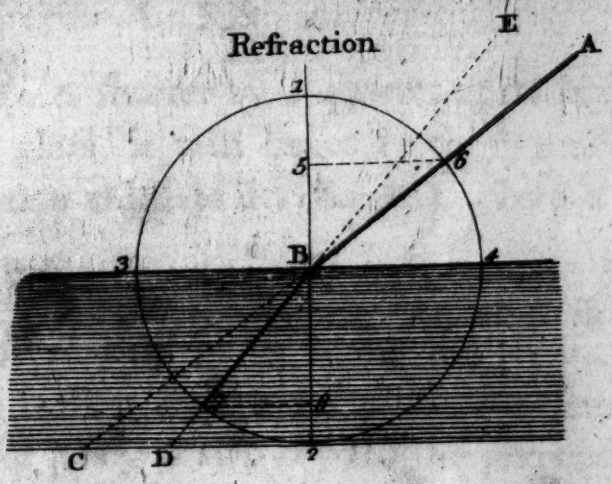
OBSER-

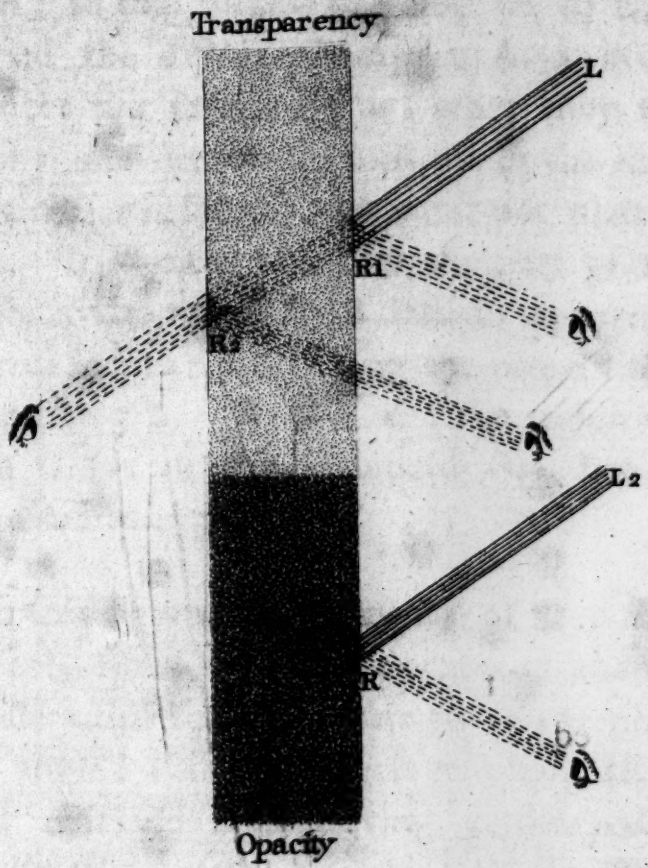
OBSERVATIONS ON THE PLATES

BELONGING TO LECTURE XIV.

PLATE I. REFRACTION. This figure ſhews the attractive effect of different mediums on rays of light. If A B, be a ray ſuppoſed paſſing in the air in one uniform direction, when arrived exceeding near the point B, it will feel the influence of the medium 3 B 4; and will be drawn by it out of that courſe it would follow (as A B C) were no ſuch denſer medium preſent; and will now be inclined toward the *perpendicular* (1 5 B 8 2), and deſcribe the line B 7 D; varying its paſſage the diſtance between C and D. The reaſon of this is, that the force of the attraction of this medium (and all others), being *perpendicular* to its ſurface, draws the ray as near as it can to its own direction, *i. e.* towards the perpendicular.

If around B, as a centre, be deſcribed a circle, as 1 2 3 4, and where that circle cuts the incident ray A B, and the refracted ray B D, parallel lines be drawn to the perpendicular, as 5 6, and 7 8, the proportion of theſe lines to each other will inform us of the quantity and force of the different refractive powers of the two mediums. If the refraction be out of air into water, the line 7 8 will be to the line


Refraction
E
A
1
5
6
B
3
4
8
C
D
2


Transparency
L
R1
R2
L2
R
Opacity

5 6, as 3 to 4 (*i. e.* ſhorter by a quarter of its length). If out of air into glaſs, it will be as 11 to 17; or nearly as 2 to 3 (loſing one third of its length). Into a diamond greater ſtill.

This figure may be *reverſed* in its idea; and we may ſuppoſe the ray of light paſſing from a denſer medium into a rarer; where, inſtead of being drawn toward the perpendicular, it is deflected toward the *horizon*; its firſt courſe being D B, its latter courſe B A; ſo that inſtead of going on to E, its paſſage is now varied the diſtance from E to A. It is clear that all circumſtances are reverſed from what they were before, and were any one deſirous to look along the line B D (ſuppoſing it a ſtick for inſtance), he muſt not place his eye at E, but at A. It is clear alſo that the part of ſuch ſtick, which is beneath the water, will loſe in appearance one quarter of its real length; ſuch being the proportion of the line 7 8, to the line 5 6. We ſee alſo the reaſon why A not only ſees to C (as in air he would do), but alſo much *deeper* in the fluid as B 7 D.

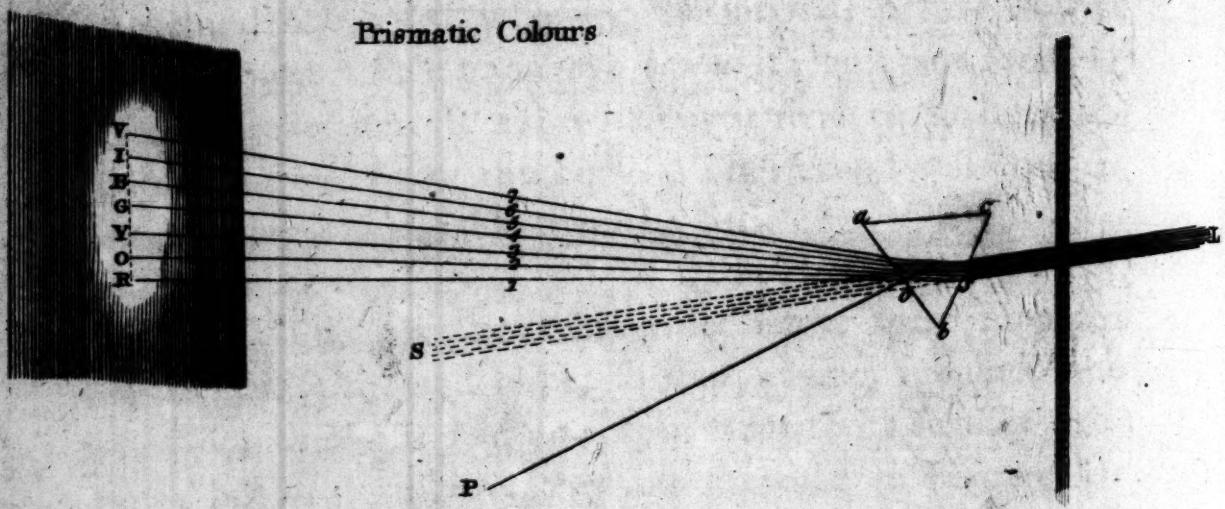
TRANSPARENCY. In this figure, L is a pencil of rays ſtriking a ſuppoſed ſurface, from which a portion of them is *reflected*, which renders this ſurface viſible to an eye placed at a correſponding angle: this is the firſt reflection (R 1). But the remainder of theſe rays, having accommodated themſelves to that direction impoſed on them by the attractive power of this body, paſs *through* it; and at its *further* ſurface

face are again divided, part passing in to whatever medium may be behind the body, whereby the internal nature of the body becomes visible to an eye *beyond* it; and part forming a second reflection (R 2); whereby it renders the same visible to an eye *before* the body. The second reflection is always more considerable than the first.

OPACITY. The pores in the former figure were supposed similar, uniform, and alike, so that having sustained one inflection, the light had no impediment to its further progress; but in this figure, they are supposed to be irregular in their positions, their forms, their sizes, &c. So that after having accommodated itself to what may be at the surface of this body (as R), it has also to vary its course for a second set of pores, then for a third, &c. till it is totally stifled and disappointed in its endeavours to find a passage.

PLATE

Prismatic Colours



Proportions of the Colours.

Double Refraction

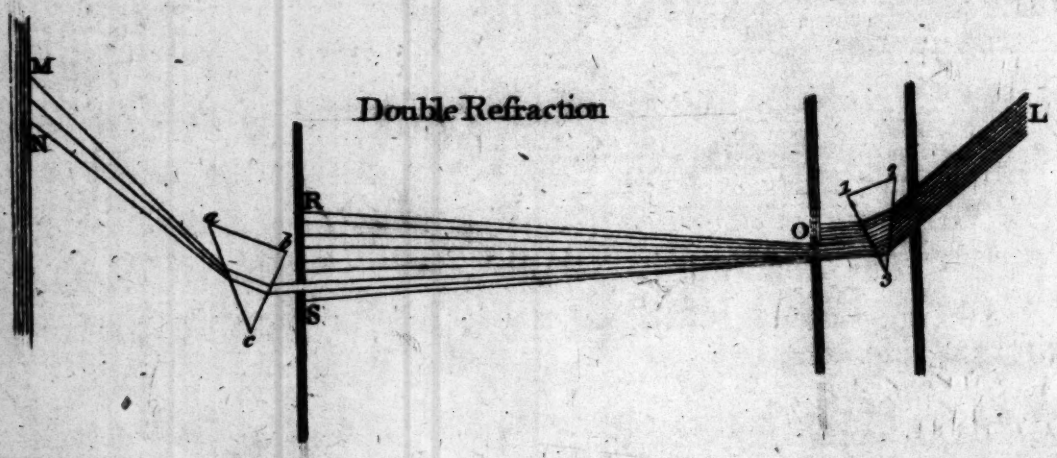


PLATE II.

PRISMATIC COLOURS. Though a ray of light feels the attraction of a medium denſer than that in which it is moving, yet as that ray is a mixture, ſome of its parts are more influenced than others, as appears by this experiment: L is a pencil of rays paſſing through a hole in a window-ſhutter into a darkened room (as ſuppoſed in the Lecture), where they are received on a priſm *a*, *b*, *c*, falling on it at *s*. The ſuperior denſity of this medium immediately inflects them from their true courſe (to S), and they paſs out at the further ſide of this medium in a ſtate of ſeparation, forming the coloured image, R, O, Y, G, B, I, V, on which we obſerve, that thoſe particles of light which depict the red (R), are *always neareſt* to the perpendicular (P) of that ſide of the priſm (*a*, *b*) from whence they iſſue, let the medium be what it may. Next to the red are the orange (O), then the yellow (Y), green (G), blue (B), indigo (I), and laſtly the violet (V).

This order is ſo conſtant, that were the letters away, and merely the figures 1 2 3 4 5 6 7 marked on the lines, any perſon converſant with the ſubject, would at once pronounce, that the ray 1 would be the red, the ray 2 the

orange, 3 the yellow, and ſo on, according to their diſtance from the perpendicular (P).

The *proportions of the Colours*, are not all equal in regard of the ſpace they occupy; but, as appears in this figure, the orange is but ſmall, while the green, blue, and violet are large.

DOUBLE REFRACTION. This experiment is that by which Sir ISAAC NEWTON thought his doctrine of light and colours abſolutely demonſtrated, and therefore he termed it *experimentum crucis*. L is a pencil of rays, paſſing as before through a hole in a window-ſhutter, and falling on a priſm 1 2 3, whereby they are ſeparated into their primary colours; near this priſm place a board (as O) with a hole in it, ſo as to let only one kind of ray paſs through it at once; this ray will in conſequence be prolonged from O to an oppoſite part of the room, as R and S. If in R S be made a perforation, ſo as to admit but a ſmall part of the coloured ray, that part will be received on a priſm behind R S (as *a b c*). If the firſt priſm (1 2 3) be turned on its axis, in the order of the figures, it is clear that each ray in its order will paſs through O to R S; and through this perforation alſo, to the ſecond priſm *a b c*. By this priſm each will be refracted (as entering a denſer medium than that it quits), and this refraction will be, as before, leſs influential on the red rays than on the others; ſo that whereas the violet will riſe to M, the red will only riſe to N; the intermediate colours, being intermediate ſtill, exactly

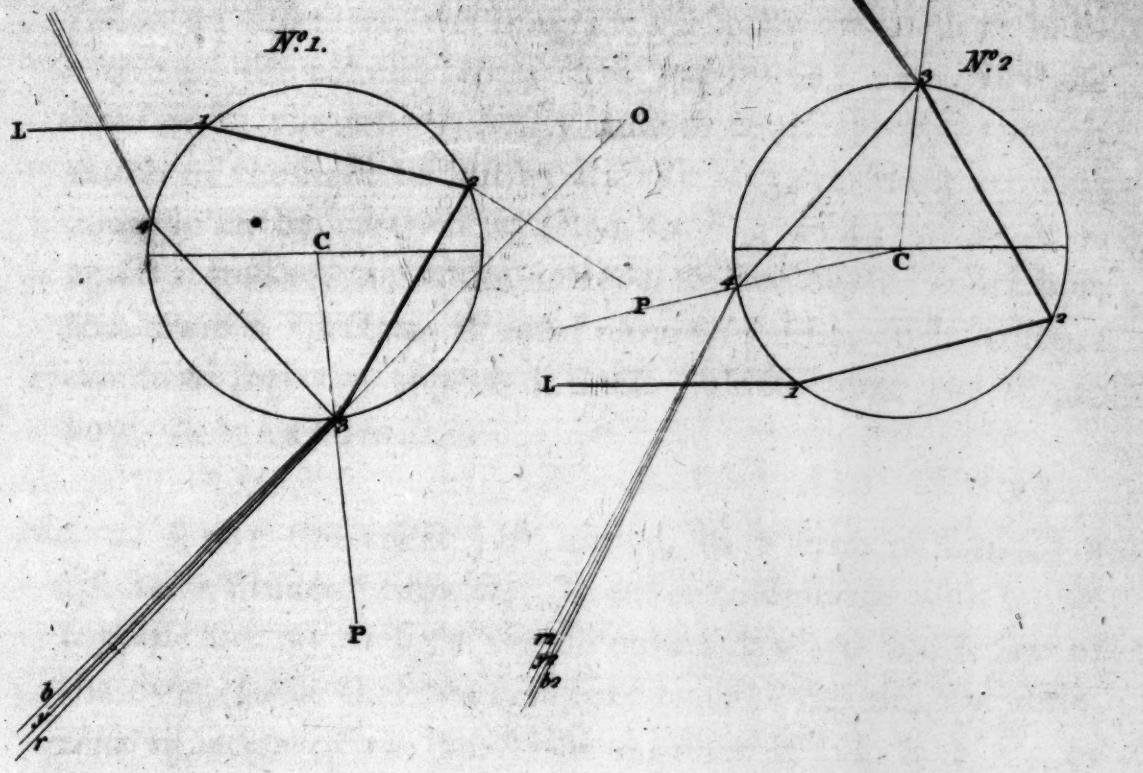
actly as before. Which ſeems to prove, that if theſe rays, when ſeparated, are yet affected by the attraction of the glaſs in various proportions of force, they have certain *eſſential* and *conſtant* differences between themſelves: of which a difference in ſize, and perhaps alſo in denſity, ſeems to be aſcertained by the principles of attraction. As all the rays maintain their ſeveral colours, and though a ſecond time refracted, yet are red, orange, &c. ſtill, no further change in their properties, as light, is to be expected.

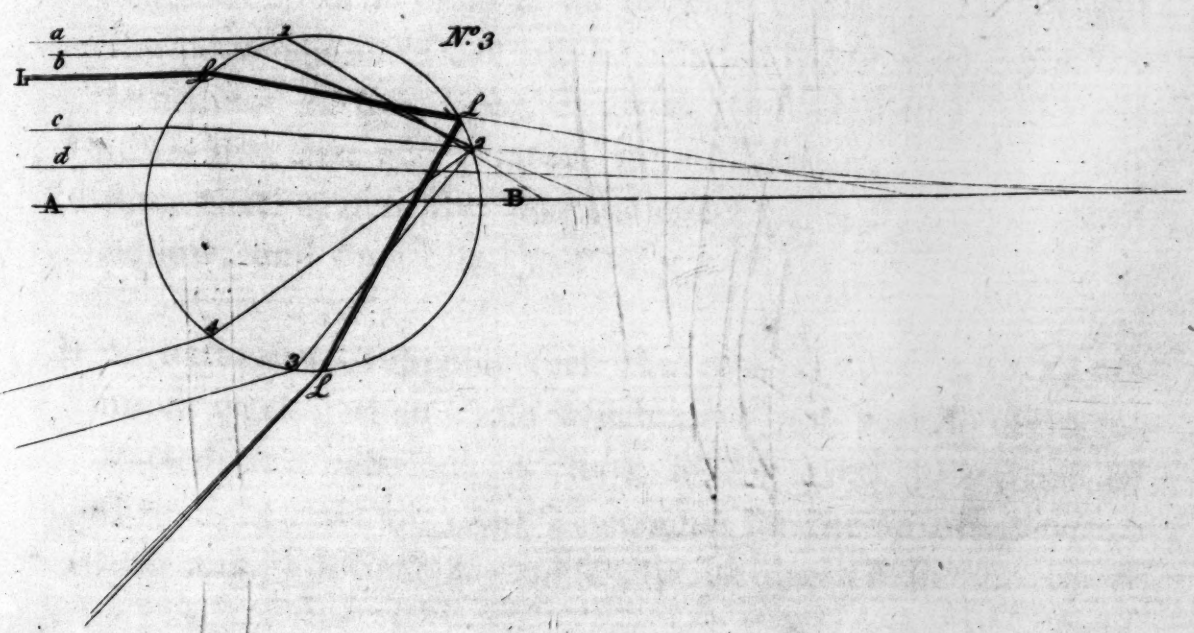
PLATE-

PLATE III.

WE have already ſtated, that a ray of light, paſſing out of air into water, will be attracted by the water as a denſer medium, and deflected from its courſe (Plate I. fig. 1); alſo, that from the further ſide of a tranſparent body is by much the moſt conſiderable reflection of light (Plate I. *Tranſparency*, R 2); alſo, that a ray of light paſſing through certain mediums, is, at its exit into a rarer medium, diverged into its primary colours (Plate II. *Priſmatic Colours*). We have now to combine theſe three principles, in order to account for the generation of a RAINBOW: which is merely a natural inſtance of priſmatic ſeparation of colours.

No. 1. L is a ray of light, which ſtriking on a ſpherical drop of falling rain, inſtead of continuing its courſe to O, is by the attraction of the drop, as a denſer medium, inflected to 2, where ſome of it paſſes out; but the remainder is reflected from 2 to 3, where it iſſues ſeparated into its component colours. Now, in order to know which colour we are to expect in any ſuppoſed point, we are to recollect, that the *neareſt* to be perpendicular (C 3 P) is red, and the *furtheſt* violet; theſe form the RAINBOW.—[In order to avoid confuſion


N°1.
L
O
C
P
N°2
C
P
L


N°3
a
b
L
c
d
A
B

fuſion on the plate, the letters *r y b* only are uſed, as indicative of the colours red, yellow, and blue; ſince, if theſe iſſue right, the others muſt follow of courſe.] But though much of the light be loſt by its exit at 3, yet there remains enough to be further reflected from 3 to 4; where it is again refracted, and iſſues in ſeparated colours. It is clear, that were a ſpectator ſituated *above* this drop, theſe colours would to his eye appear diſtinct. Theſe form the upper bow, or WATER-GALL.

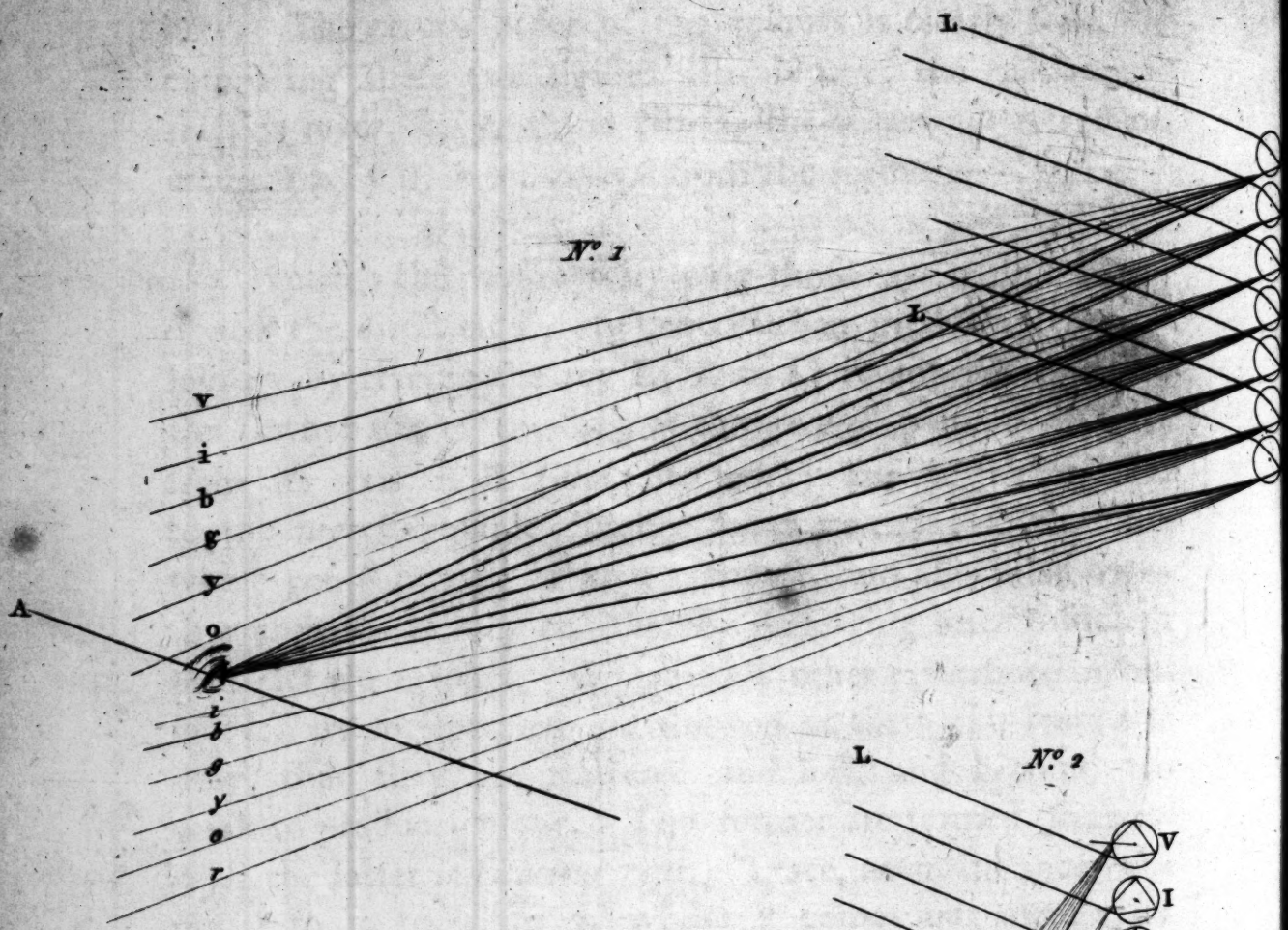
No. 2. ſhews the effect juſt hinted, in a drop as ſeen by a ſpectator ſituated *below it*. In order to deſcribe which, we ſuppoſe the ray of light which enters toward the *bottom* of the drop, to be that we deſign to trace; becauſe, the different ſituation of the ſpectator requires it. L is a ray of light ſtriking the drop at 1, refracted to 2, reflected to 3, where moſt of it iſſues in its primary colours; that neareſt the perpendicular (C 3 p), as uſual is red (r y b); but the remainder of this light, is from 3 reflected to 4, where it iſſues in a ſtate of ſeparation as to its colours; and, as before, that neareſt the perpendicular (C 4 P) is red; then yellow, and then blue (as r 2, y 2, b 2).

It is natural to ſuppoſe, that the rays r 2, y 2, b 2, are much weaker than thoſe which have not been ſo often refracted and reflected, or have loſt ſo great proportion of their light: which remark accounts for the apparent weakneſs and indiſtinct faintneſs always noticed in the upper

bow. The *reverſe* order of the colours is clearly ſeen, by comparing theſe two figures. In No. 1, the *rainbow* refraction reads, b, y, r; in No. 2, the *water-gall* refraction reads, r 2, y 2, b 2; *reverſe* from the former.

No. 3. explains the reaſon why only thoſe rays which fall *in* or *near* the direction *L*, are concerned in producing the colours. By tracing the ray L, *L* to *L*, it appears to ſtrike the further ſide of the drop at the *greateſt* poſſible diſtance from its axis A B (*above* its axis); and to be *reflected* to the *neareſt* poſſible diſtance *below* its axis: ſo that the whole pencil of rays is kept compact, and aſſembled together as much as may be, thereby preſerving force ſufficient to depict the colours. Whereas all other rays above or below L, are ſo ſeparated and thinned at their exit from the drop, that they are ſcattered and loſt, and become too weak to produce colour. The former are termed *efficacious rays*, the latter *inefficacious rays*. Trace, as an inſtance, the ray *a* to 1, to 2, to 3, where it comes out alone; for though the ray *b* ſtrikes the drop originally not far from *a*, yet after its refractions, &c. it comes out nearly at 4, which is too far from 3 to produce any effect. The ſame reaſoning applies to the lower rays *c*, *d*.

PLATE


L
L
N.º 1
V
i
b
g
y
o
r
A

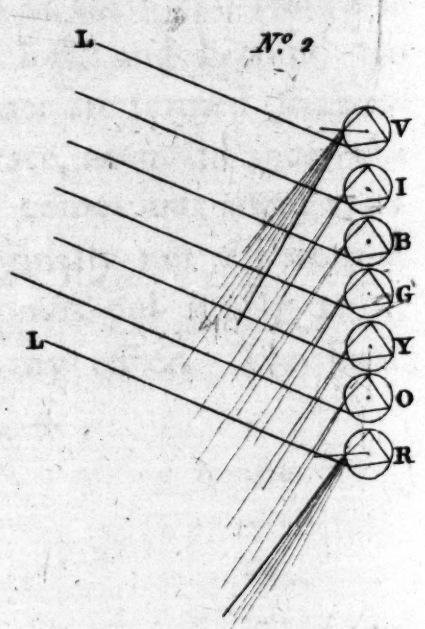

L
N.º 2
V
I
B
G
Y
O
R
L

PLATE IV.

AS it is evidently impoſſible, by reaſon of the divergence of the rays, that any ſingle drop ſhould exhibit *all* the RAINBOW colours to the eye of a ſpectator at the ſame time, in this example, we ſuppoſe ſeveral drops, or ranges of drops, one *above* another; and it appears that, as the drops at different heights preſent different colours, all the colours are preſented by means of each range furniſhing that proper to thoſe of its rays which ſtrike a ſpectator's eye.

L L are rays of light, ſtriking the drops nearly at the top; theſe being refracted, and reflected, come out diverged: that neareſt the perpendicular drawn from the center of the drop, is red (R), which, of all that iſſue from this drop, alone ſtrikes the eye of the ſpectator; the others being diſperſed *around* the eye (as o, y, g, b, i, v.), but not reaching it. The ſecond drop is ſo ſituated, that not its ray neareſt the perpendicular, but that *next* to it, reaches the ſpectator's eye; all the others being loſt. This depicts the orange (O). The yellow (Y) rays are next above that; all others from this drop being uſeleſs; the green (G) is the center ray; the blue (B) is the upper ray but two; the indigo (I) the upper but one; and the violet (V), as moſt refracted, is that ray *furtheſt* from the perpendicular drawn from the center of

the drop; all the other rays of this drop falling *below* the eye (as *i*, *b*, *g*, *y*, *o*, *v*,); consequently are inefficacious. After consideration of the foregoing plates, especially No. 1, Plate III. this figure needs no further explanation.

A is a ray of light parallel to L L, passing through the eye of a spectator; and thereby becoming the axis from which the angular bearings of the refractions, &c. are to be calculated: the lower angle, A V, being 40 deg. 17 min.; the upper angle, A R, being 42 deg. 2 min.

No. 2, is a similar representation of the colours of the *water-gall:* but the colours are contrary in their order. The drop which appears red (R) being now *lowest*, the orange *above* that, and so on, till the violet takes the upper place among the drops.

It is evident that by the same process as in No. 1, the *under* ray of the *upper* drop is violet; the next above it indigo; and so on, till the *upper* ray of the *lowest* drop is red. L L is light as before.

PLATE

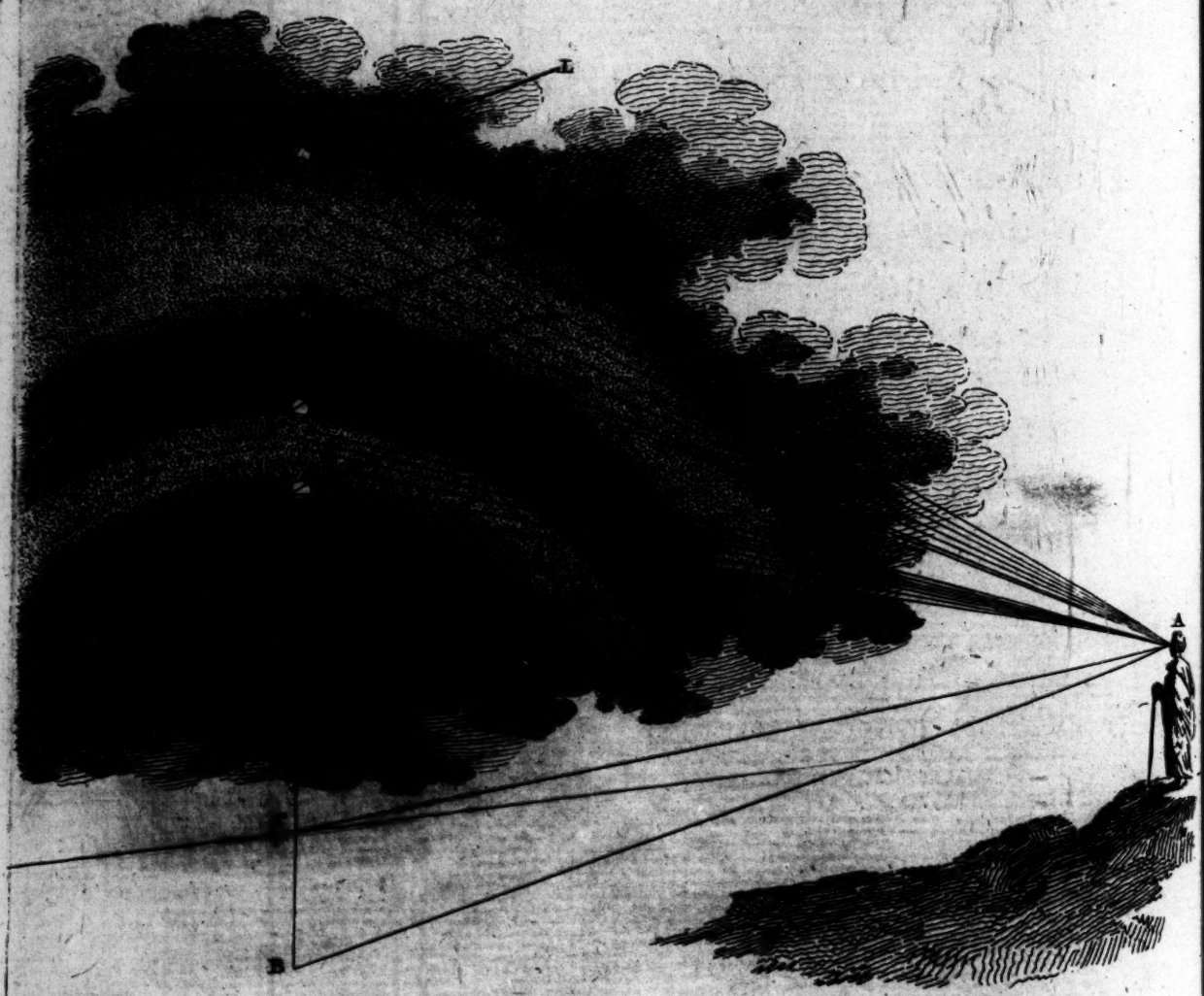


PLATE V.

IS merely a combination of the principles adduced in the foregoing plates, as they occur in nature. A is a ſuppoſed ſpectator; L L L rays of light from the ſun; A B a line parallel to ſuch rays, and which paſſing through the eye of A, becomes the axis from which the angles of the bows are to be calculated. B is the diſtance of the bows; and their center, as they appear at an equal angle from it on all ſides, thereby becoming *circular*. B C is the altitude of the ſun above the horizon. If the ſun were *at* the horizon, the lines A B, and A C, would *coincide*; conſequently the bows would appear complete ſemicircles: when the ſun is below the horizon, the bows are proportionately *elevated*; when the ſun is high above the horizon, the bows are proportionately depreſſed. When he is higher than the meaſures of the permanent angles neceſſary to form the *bow*, the bow is below the ſpectator's horizon; conſequently inviſible; ſo that during the middle parts of many days in ſummer, no rainbow can appear, or ought to be expected, till the ſun deſcends from his meridian altitude to the neceſſary angle for forming the bows.

The diſtance from B to D, is 40 deg. 17 min.; from D to C, that is to ſay, the breadth of the interior bow, is 1 deg. 45 min.

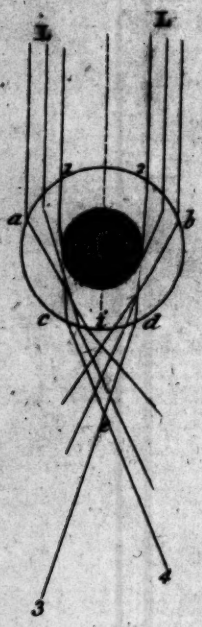
min. making B C 42 deg. 2 min.; from E to F is that ſpace from which no refracted colours arrive at the ſpectator's eye; it being too *high* for thoſe which form the lower bow, and too low for thoſe which form the upper bow; ſo that all effects of light reſulting from falling drops here, are inefficacious to the ſpectator A. The breadth of the ſpace is 8 deg. 56 min. making B F 50 deg. 58 min.; from E to G meaſures 3 deg. 12 min.; ſo that the upper bow is much broader than the inferior (nearly double), and the diſtance B G 54 deg. 10 min.; above which angle no refraction of light is viſible to A,

The diſtance and dimenſion of the bows, have hitherto been calculated, as occaſioned by a ſingle ray of light falling upon them; but when we conſider, that rays from all parts of the ſun fall upon theſe drops of rain, we muſt add to our calculation the apparent dimenſions of that luminary; which being about 30 minutes, or half a degree, increaſes the breadth of the bows half a degree each, and decreaſes the diſtance between them half a degree; ſo that the interior bow will now meaſure 2 deg. 15 min.; the interval 8 deg. 26 min.; the exterior bow 3 deg. 42 min. Alſo the greateſt ſemidiameter of the interior bow (B E) 42 deg. 17 min.; the leaſt of the exterior bow (B F) 50 deg. 43 min.

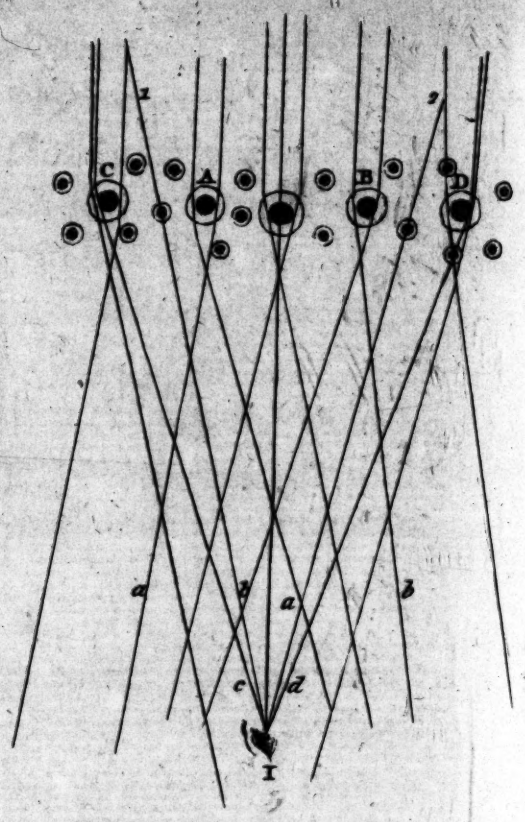
PLATE

HALO

N°2.



N°1.



MAGNET

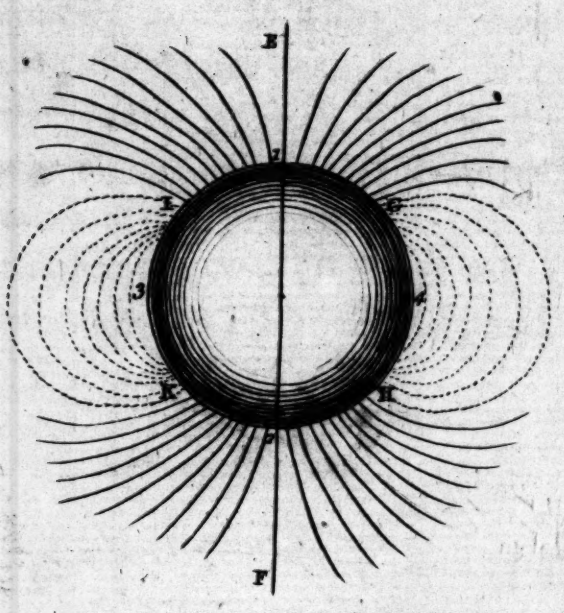


PLATE VI.

THE formation of HALOS has been accounted for by Mr. HUYGENS, by ſuppoſing, that the atmoſphere may contain floating in it, certain globules, whoſe *external coat* is formed of tranſparent ice or water, while its *central* parts are opake, being formed of particles of ſnow: theſe ſnowy particles being the center, around which the adjoining vapours adhere. It follows, that no effects of refracted light, are to be expected from rays attempting to paſs through the center; but from thoſe paſſing through the ſides.

No. 1, *a* 1 2 *b d c*, repreſents ſuch a globule; L L rays of light impinging upon it. L 1, L 2, are rays, which ſtriking the globule in 1 and 2, are conſequently refracted, as entering a denſer medium, and iſſue at *c* and *d*; where being again refracted, they croſs each other in *e*; whoſe diſtance from the globule is ſomewhat leſs than half its diameter; theſe rays being prolonged to 3 and 4, it follows, that no light can reach an eye placed any where in the angle 3 *e* 4, be theſe lines as long as they may. We obſerve, that *c* and *d* is the furtheſt diſtance from *i*, at which any ray can paſs; for the rays L a, L b, are turned much further out of their original courſes, and come out *ſpread* much beyond 3 and 4, conſequently, cannot reach the eye placed within 3 and 4.

No. 2, Repreſents the effect of a combination of ſuch globules. Rays from the center drop, as appears by the figure,

figure, cannot reach the eye at I, nor can any within the angles I 1, and I 2, (correſpondent to 3, 4, in No. 1.) for the rays from A (*a a*) are wide of the mark; as are thoſe (*b b*) from B. But the rays from C, and D, being *without* 1, 2, reach I at *c*, and *d*; and being thoſe particles which have leaſt felt the refractive influence of the medium through which they have paſſed, are conſequently red.

It is obvious, that the angles 1 I 2, are a cone, within which no light is refracted to the eye; but *around* whoſe *circumference* effects of refraction are to be expected.

MAGNET.

If a magnet be laid under a piece of fine paper, upon which fine ſteel filings are ſtrewed very thin, by means of a very gentle ſtriking continued on the paper, the particles of ſteel will arrange themſelves on the paper in forms correſponding to thoſe of this figure. 1, 2, Are the *poles* of the magnet; 3, 4, what may be termed its *equator*. When direct with the magnetical axis 1, 2, the ſteel filings are ſtrait, as E and F, but on each ſide, from 1 to I and G, and from 2 to K and H, they bend conſiderably; from I and K to 3, and from G and H to 4, they gradually form themſelves into yet more crooked curves: whence it is concluded, that the natural courſe of the magnetic fluid is along the polar axis, F E; and very weak towards 3 and 4. Theſe principles applied to the globe of the earth, account very readily for the polar *direction* of the magnetized needle. To account for the *variation* of the needle, we muſt ſuppoſe a correſpondent variation of the magnetic poles of the globe.

End of the FIRST *Series of Lectures.*

SURVEYS OF NATURE.

SECOND SERIES OF LECTURES.

LECTURE I.

LADIES AND GENTLEMEN,

THE knowledge of what preceded us, and of what paſſes remote from us, is among thoſe acquiſitions which place the talents and induſtry of mankind in the moſt conſpicuous point of view; and when it has for its object occurrences of great magnitude and general importance, when it traces the more extended operations of nature, and by compariſon of the paſt and the preſent, in a manner anticipates the future, we cannot but regard it as among our moſt valuable and intereſting poſſeſſions. With this ſentiment we come now to the conſideration of our terreſtial dwelling; on ſome of whoſe peculiarities as a planet we have already be-

ſtowed our attention; obſerving, its inclination, its rotation, and the variation of ſeaſons upon it: theſe motions it poſſeſſes in common with other planets, but we are prevented by diſtance from intimate acquaintance with them, while by reſidence we are naturally qualified for more accurate knowledge and cloſer inſpection of the earth.

We have already divided the earth into three zones, belts, or diviſions, whoſe natures were well expreſſed by their appellations; as TORRID, TEMPERATE, and FROZEN; theſe will be of great uſe to us in the progreſs of what remains to be delivered, and will generally regulate our obſervations.

The firſt particular which would ſtrike a ſpectator in ſurveying the earth, is, its *unevenneſs*, its mountains, and its valleys (theſe we diſtinguiſh in the moon, though little elſe is ſubmitted to our ſight); next its diſtinctions of land and water, including the verdure of the former, and its interſections by the latter. On the firſt of theſe we propoſe to offer a few remarks in this diſcourſe.

We begin by ſuggeſting, that the equatorial, or middle part of the earth, is remarkable for the dimenſions of its eminences (mountains), for the depths of its ocean, and the magnitude of its interſections (rivers); that here, mountains are higheſt above the level of the ſea, the ſea higheſt above the level of other ſeas, its bottom much below the bottom of other ſeas, and its rivers moſt capacious. Here are what we may term *extremes*; flat and extenſive deſarts, or high and elevated mountains; few, if any, gentle declivities, or

eaſy

eaſy aſcents; not *hills*, but maſſes riſing to the ſkies. Here are rather torrents than rivers; no gentle ſtreams, no brooks ſecretly gliding, but either parched waſtes, or rapid, and overwhelming floods.—In ſupport of theſe remarks, I ſhall juſt hint at ſome of the moſt extraordinary of both kinds.

As a ſpecimen of what mountains may be, take the accounts given us of the ANDES in South America; the moſt mountainous of mountains! extending from 10 deg. north latitude, to 55 ſouth latitude; conſequently, being in part of their courſe properly equatorial.

"Theſe mountains," ſays OVALLE, "are a prodigy of nature, and without parallel in the world, being a high chain of hills 1500 leagues in length, and 40 leagues broad, with many intermediate valleys: the aſcent is ſo prodigious that we employ three or four days in arriving at the top of them, and as many more in the deſcent, that is, ſpeaking properly, and only of the mountain; for otherwiſe it may be affirmed, that one begins to mount even from the ſea-ſide, becauſe all the way, which is about 40 leagues, is nothing but an extended ſhelving coaſt, for which reaſon their rivers run with ſuch force, that their ſtreams are like mill-ſtreams, eſpecially near their ſources.

"When we come to aſcend the higheſt part of the mountains, we feel an air ſo piercing and ſubtil, that it is with much difficulty we breathe, which obliges us to fetch our breath quick and ſtrong, and to open our mouths wider than ordinary, applying to them likewiſe our handkerchiefs to condenſe our breath, and break the extreme coldneſs of the air,

and

and ſo make it more proportionable to the temperament which the heart requires. This I have experienced every time that I have paſſed thoſe mighty mountains.

"Don Antonio de Herrera, and other writers obſerve, that thoſe who paſs the Andes in Peru, ſuffer great retchings and vomitings; becauſe nothing produces ſo great an alteration at once as a ſudden change of air, and that of the mountains being ſo unproportioned to common reſpiration, produces in thoſe who paſs over it thoſe ſurprizing and painful effects. 'Tis true, that in that part of the Cordilleras in Peru which they call Periacaca, there may be a concurrence of other cauſes, and a particular diſpoſition of the climate, to which may be attributed ſome of theſe effects: for if they were to be attributed only to the height of the mountain, we that paſs it in Chili ought to find thoſe inconveniencies as much or more, becauſe the mountain is higheſt without compariſon here; and yet I never endured thoſe retchings, or vomitings, nor have ſeen any of thoſe motions in others, but only the difficulty of breathing, which I have mentioned.

"Others experience other effects, which I have often heard them relate; but certain it is, we go through theſe mountains, treading as it were upon clouds; when we aſcend to the higheſt we can no longer ſee the earth for the clouds below, but the heavens are clear, and the ſun ſhines out in its full luſtre.

"The Iris, or rainbow, which in the valleys we ſee croſſing the heavens, we obſerve from this height extended under our feet; nor is it leſs admirable, that while we travel over theſe hills,

hills, and ſee at a diſtance tempeſts and ſtorms falling into the valleys beneath, the ſerenity over our heads exceeds that of the fineſt ſummer's evening.

"There are, in this Cordilleras, or chain of mountains, ſixteen volcanos, which at ſeveral times have broken out, and cauſed effects very terrible and aſtoniſhing to all the country. Amongſt the reſt, that which happened in the year 1640, is worthy to be remembered; it broke out in the enemy's country, in the territory of Cacique ALIANTE, burning with ſo much force, that the mountain cleaving in two, caſt forth pieces of rocks all on fire, with ſo horrible a noiſe, that it was heard many leagues off, juſt like the going off of cannons.

"The difference which may be obſerved in paſſing the Cordilleras between each ſide of the mountain is ſo great, that they ſeem two different worlds (the eaſt and weſt parts). One would think heaven had placed theſe mountains here to divide them as a wall, and keep off from the weſt all the ſtorms and ill weather of the eaſt. Any one that travels to the top of them may experience this clearly, for there he diſcovers both horizons, and when he looks to the eaſt, all is covered with great vapours, which ſeem to hinder the light, and ſhadow all the country; and at the ſame time looking weſt, the heavens are ſo bright, that it cauſes pleaſure and joy to look on them. The eaſt ſide is full of a cloudy thick air, which engenders ſtorms and hail, with horrible thunders and lightnings: on the other ſide, in the weſt, there is not a cloud to be ſeen, but all is clear and bright, as if in the hea-

vens

vens themſelves there were ſuch a partition as the Cordilleras to divide the climates; and upon earth there is a difference in the trees, plants, and animals on each ſide.

"A curious obſerver contemplating once from this height, this remarkable difference, ſaid, that nature, in the fabrick of this part of the world, ſeemed to have turned her back upon the eaſtern provinces, and looked with her face only upon Chili, giving bleſſings with both hands to this laſt, and leaving the other as it were diſinherited, and grieving at the pre-eminency of its elder brother. In going down to the eaſtward alſo, there are fewer fountains and rivers, and thoſe muddy, the face of the land melancholy, without ſo much as one green tree to recreate the ſight, nor any pleaſant verdure; and when at laſt you meet with ſome, as in the valley of Uſpallata, the heats begin to be intolerable, but when we go to the weſt it is quite otherwiſe; for as ſoon as we begin to deſcend, we meet with lovely ſprings, the trees are green, the groves fragrant and pleaſant, and the little valleys are like ſo many reſting-places in that great ſtair-caſe. From the very foot of the mountains one feels the mildneſs of the ſea-air, and one is charmed with the harmony of the birds and other delightful objects."

To this I ſhall add the later account of Don ANTONIO DE ULLOA, who was one of the gentlemen ſent to meaſure an equatorial degree.

"The ruggedneſs of the road from Tariguagua, leading up to the mountain, is not eaſily deſcribed. In ſome parts, the declivity is ſo great, that the mules can ſcarce keep their footing;

footing; and in others, the acclivity is equally difficult. The trouble of having people going before to mend the road, the pains ariſing from the many falls and bruiſes, and the being conſtantly wet to the ſkin, might be ſupported, were not theſe inconveniencies augmented by the ſight of ſuch frightful precipices, and deep abyſſes, as muſt fill the mind with ceaſeleſs terror. There are ſome places where the road is ſo ſteep, and yet ſo narrow, that the mules are obliged to ſlide down, without making any uſe of their feet whatſoever. On one ſide of the rider, in this ſituation, riſes an eminence of ſeveral hundred yards; and on the other, an abyſs of equal depth; ſo that if he in the leaſt checks his mule, ſo as to deſtroy the equilibrium, they both muſt unavoidably periſh.

"After having travelled about nine days in this manner, ſlowly winding along the ſide of the mountain, we began to find the whole country covered with an hoar froſt; and an hut in which we lay had ice on it. Having eſcaped many perils, we at length, after a journey of fifteen days, arrived upon the plain, on the extremity of which ſtands the city of Quito, the capital of one of the moſt charming regions upon earth. Here, in the center of the torrid zone, the heat is not only very tolerable, but in ſome places the cold alſo is painful. Here they enjoy all the temperature and advantages of perpetual ſpring; their fields being always covered with verdure, and enamelled with flowers of the moſt lively colours. However, although this beautiful region be higher than any other country in the world, and although it took up ſo many days of painful journey in the aſcent, it is ſtill overlooked by

tremendous mountains; their ſides covered with ſnow, and yet flaming with volcanoes at the top. Theſe ſeem piled one upon the other, and riſe to a moſt aſtoniſhing height, with great coldneſs. However, at a determined point above the ſurface of the ſea, the congelation is found at the ſame height in all the mountains. Thoſe parts which are not ſubject to a continual froſt, have here and there growing upon them a ruſh, reſembling the geniſta, but much more ſoft and flexible. Towards the extremity of the part where the ruſh grows, and the cold begins to encreaſe, is found a vegetable, with a round bulbous head, which, when dried, becomes of amazing elaſticity. Higher up the earth is entirely bare of vegetation, and ſeems covered with eternal ſnow. The moſt remarkable mountains are, that of Cotopaxi (already deſcribed as a volcano), Chimborazo, and Pichincha. Cotopaxi is more than three geographical miles above the ſurface of the ſea: the reſt are not much inferior. On the top of the latter was my ſtation for meaſuring a degree of the meridian; where I ſuffered particular hardſhips, from the intenſeneſs of the cold, and the violence of the ſtorms. The ſky around was, in general, involved in thick fogs, which, when they cleared away, and the clouds, by their gravity, moved nearer to the ſurface of the earth, they appeared ſurrounding the foot of the mountain, at a vaſt diſtance below, like a ſea encompaſſing an iſland in the midſt of it. When this happened, the horrid noiſes of tempeſts were heard from beneath, then diſcharging themſelves on Quito, and the neighbouring country. I ſaw the lightnings iſſue from the clouds, and heard

the

the thunders roll far beneath me. All this time, while the tempeſt was raging below, the mountain top, where I was placed, enjoyed a delightful ſerenity; the wind was abated; the ſky clear; and the enlivening rays of the ſun moderated the ſeverity of the cold. However, this was of no very long duration, for the wind returned with all its violence, and with ſuch velocity as to dazzle the ſight; whilſt my fears were encreaſed by the dreadful concuſſions of the precipice, and the fall of enormous rocks; the only ſounds that were heard in this frightful ſituation."

Olympus and Ida may be more claſſical mountains than the Andes, but in terror, as in dimenſions, they ſhrink by compariſon into mole-hills.

The Mountains of the Moon in Abyſſinia, are ſo high as to furniſh from one ſide, the river Nile, which runs through Egypt; and from another ſide, the river Niger, which running weſt paſſes Africa. The mountains of Monomotapa, Mount Caucaſus, and its connections; the Pyreneans, the Alps, and others of conſiderable dimenſions, may be reckoned rather to the middle of the earth, than to its extremities.

America, as it exhibits the moſt lofty mountains, alſo ſupplies the largeſt rivers. The foremoſt of theſe is the great river Amazons, which, running within a few degrees of the equator, and parallel to it, from its ſource in the lake of Lauricocha, to its diſcharge into the weſtern Ocean, performs a courſe of more than twelve hundred leagues. The breadth and depth of this river is anſwerable to its vaſt length; being

ordinarily two or three leagues broad, and thirty or forty fathoms deep; where its width is moſt contracted, its depth is augmented in proportion. So great is the body of its waters, that other rivers, though before the objects of admiration, are loſt in its boſom. It proceeds, after their junction, with its uſual appearance, without any viſible change in its breadth or rapidity. In ſome places it diſplays its whole magnificence, dividing into ſeveral large branches, and encompaſſing a multitude of iſlands; and, at length, diſcharges itſelf into the ocean, by a channel of an hundred and fifty miles broad. This prodigious efflux of water has anſwerable effects on the ocean itſelf; ſo that veſſels may take up freſh water at two hundred miles diſtance from land.

The river Oroonoko, north of the equator, is ſeven hundred and fifty leagues in length, from its ſource to its diſcharge. If we ſeek other tropical rivers, we might mention the Gambia, the Ganges, and others, to prove our aſſertion.

It may eaſily be ſuppoſed, that, proportionate to the elevation of the mountains, and the magnitude of the rivers, is the depth of the ocean beneath the equator; it is a rule generally admitted among ſeamen, that in proportion to the boldneſs of a ſhore is the depth of water adjoining; the ſame idea may be extended to the ocean itſelf, and we may well expect (as in fact experience proves) that here are the deepeſt ſeas, and here the greateſt force of the waves. The ſea is not every where equally deep, but its pits and caverns are perhaps not totally unlike a reverſe idea of mountains; vaſt ſinkings, inſtead of vaſt riſings; immenſe hollows, inſtead of

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immenſe protuberances. Thus it appears, that the extreme inequalities of our planet are in its middle part; the operations of nature ſeem here on a larger ſcale; with a kind of magnificent and terrible greatneſs, here ſhe delights to aſtoniſh puny man, and to diſplay her powers to his bewildered obſervation. —Many of the tropical mountains are above two miles perpendicular height from the level of the ſea; and ſome (as above aſſerted) three miles high. By what we can eſtimate, three miles is the greateſt depth of the ſea; and that only in particular places: perhaps on an average, the ſea ſcarce exceeds one mile in depth, moſt parts of the ocean having been occaſionally ſounded, by lines of leſs extent.

As we advance into the temperate zones, on either ſide the equator, we find nature aſſuming a more moderate and uniform appearance; we have mountains indeed, but not ſo tremendous; and we have a certain proportion of lower eminences (hills); we have rivers, but are not without rivulets accompanying their courſes. Here is perhaps little leſs proportion of waters, not collected into ſuch immenſe bodies as we lately deſcribed, but diſperſed in fertilizing ſtreams throughout a country, viſiting its various diviſions, and branching out into a thouſand beneficial channels. Not that the rivers between the tropics do not receive many others in their courſes (the river Amazons receives above ſixty), but in general they are rather accumulations of floods, of heavy rains, and melted ſnows, than the union of ſprings, fountains, and ſtreams.

I ſhall juſt mention, as the greateſt rivers, the Danube,

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the Wolga, the Don, in Europe; the Huanho, the Jeniſca, the Oby, in Aſia; the Miſſiſſippi, the St. Lawrence, in North America; the river La Plata, in South America; all rivers whoſe ſources originate in temperate climates.

Around the Poles are few hills, and ſtill fewer mountains; if here and there ariſe a conſiderable one, it forms no part of any chain or continuity, has little relation to others, and ſeems belonging to no community.

Around the Poles alſo are few rivers, and not many brooks; what rivers empty themſelves into the circumjacent ſeas, riſe far in land, and are indebted to winter floods, or to melted ſnows, for ability to compare with any which we have named.

Hitherto we have conſidered mountains merely as huge elevations of parts of the earth's ſurface; we muſt not diſmiſs them, without adverting to their cauſes, their utility, and to ſeveral remarkable circumſtances connected with them.

It is not very eaſy to demonſtrate by what cauſes the preſent mountains were erected, but we know, that mountains (though probably unequal in elevation to ſome now exiſting) exiſted from the firſt; and we may juſtly ſuppoſe, that the grateful alternation of hill and dale, was by no means ſparingly beſtowed on our globe in its priſtine ſtate. So far as we are now able to trace the active cauſes capable of producing ſuch elevations, we muſt principally attribute them to the agency of *fire*, and perhaps, *water*.

I know it is a favourite principle with ſome, that all mountains are of volcanic origin; being raiſed from time to time

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by the violence of ſubterraneous fires. Others hold, that, water having worn away the interval between any two eminences, they would in proceſs of time be left ſtanding, while all around was decayed, and ſo become mountains. In ſupport of the firſt opinion, it is admitted, that volcanos have been extremely numerous; that many very deciſive tokens of their former exiſtence remain where now they are extinguiſhed; that where we ſhould little, if at all, ſuſpect ſuch inſtances, we find, either lava, which has been burnt in ſuch volcanos, or, minerals which uſually accompany volcanos now exiſting, or peculiar forms of the parts of ſuch mountains proper to volcanos, ſuch as craters, or mouths (which are now often diſguiſed by being lakes), or chaſms of great depth, or of peculiar directions. Nor are wanting, many places where volcanos ſeem to be but partly extinguiſhed, and to poſſeſs even now the principles of fire, though not exerted; theſe often furniſh particular kinds of medical baths, impregnated with the principles of arſenic, ſulphur, or other minerals. Hot baths are ſeldom on plains; but where nature ſeems to have ſuffered ſome convulſive perturbation, we find theſe relicks of former principles; amid hills, which ſeem as if they were mountains decayed, or were at ſome future period deſtined to enlarged dimenſions.

On the other hand, in all the mountains hitherto examined, are found marine bodies of various kinds; what formerly appertained to the ocean, and ſeem to have been left behind in its retreat. Foſſils that once were fiſh (and fiſh too of kinds

known to reſide in deep waters) or plants peculiar to the ſea, now imbedded in ſtone, though not perhaps ſtrictly ſpeaking become ſtone themſelves. Nor are theſe articles found but rarely, or by ſingular good fortune; they occur perpetually in ſome form or other, to whoever engages himſelf in reſearch: ſometimes indeed, they offer even without reſearch, as I am told in a rock near Folkſtone, up very high, is a *Cornu Ammonis* as large as a coach wheel.

In mentioning the *Cornu Ammonis*, I ought to remark that not a few of the foſſils, or petrifactions, preſerved by nature, belong to animals of which at this time we are ignorant; either their reſidence is ſo deep in the ocean as to defy our endeavours after acquaintance with them, prompted as we may be by curioſity or avarice; or their native ſpot is far from where the ſons of ſcience can wander in ſafety. We may therefore regard them as ſo many caſts of nature's providing, that if the ſpecies be extinct, theſe are its memorial; if it be elſewhere exiſting, they may excite our perſeverance and induſtry to acquaintance with it.

But to return to our more immediate ſubject; it is argued, that, where not a few ſcattered ſhells, but extenſive beds of the ſame ſpecies occur, there was certainly once the element proper to the fiſh. If they be ſuch ſhells as are now found belonging to freſh water fiſh, there muſt have been lakes, or rivers. If they be ſhells belonging to fiſh which cannot exiſt but in ſalt water, how can we deny that ſalt water covered the beds where they are found? It is in vain to mention their preſent elevation above the level of the ſea, or their

preſent diſtance from its ſhores; it is in vain to argue from preſent appearances, ſince if once the facts be granted (and they are undeniable), we can much more eaſily conceive of the ſea withdrawing its waves, than that fiſh ſhould live without water, that they ſhould multiply and cover a ſurface of many leagues, without the enjoyment of the element neceſſary to their exiſtence.

At Touraine, in France, more than an hundred miles from the ſea, is a plain of about nine leagues long, and as many broad, from whence the peaſants of the country ſupply themſelves with marle for manuring their lands. They ſeldom dig deeper than twenty feet, and the whole plain is compoſed of the ſame materials, which are ſhells of various kinds, without the ſmalleſt portion of earth between them. Here then, is a large ſpace, in which are depoſited millions of tons of ſhells. England is furniſhed with its beds, though not quite ſo extenſive, yet equally wonderful. "Near Reading, in Berkſhire, for many ſucceeding generations, a continued body of oyſter-ſhells has been found through the whole circumference of five or ſix acres of ground. The foundation of theſe ſhells is an hard rocky chalk; and above this chalk, the oyſter-ſhells lie in a bed of green ſand, upon a level, as nigh as can poſſibly be judged, and about two feet thickneſs." Theſe ſhells are in their natural ſtate, but they are found alſo petrified, and almoſt in equal abundance in all the Alpine rocks, in the Pyrenees, on the hills of France, England, and Flanders. Even in all quarries from whence marble is dug, if the rocks be ſplit perpendicularly downwards,

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petrified ſhells, and other marine ſubſtances will be plainly diſcerned.

In ſeveral parts of Aſia and Africa, travellers have obſerved theſe ſhells in great abundance. In the mountains of Caſtravan, which lie above the city Barut, they quarry out a white ſtone, every part of which contains petrified fiſhes in great numbers, and of ſurpriſing diverſity. They alſo ſeem to continue in ſuch preſervation, that their fins, ſcales, and all the minuteſt diſtinctions of their make, can be perfectly diſcerned.

They are found at the very bottom of quarries and mines, in the retired and inward parts of the moſt firm and ſolid rocks, upon the tops of even the higheſt hills and mountains, as well as in the valleys and plains: and this not in one country alone, but in all places where there is any digging for marble, chalk, or any other terreſtrial matters, that are ſo compact as to fence off the external injuries of the air, and thus preſerve theſe ſhells from decay.

If then in mountains no leſs than on plains, are found theſe tokens of the ocean's reſidence, it is inferred, that time was, when either the mountain was low as the level of the ſea, or the ſea overwhelmed the mountain, in common with all ſurrounding parts. Your thoughts, LADIES and GENTLEMEN, are here naturally led to that awful event, of which very few records indeed are exiſting, but many proofs; mankind have almoſt ſuffered its memory to eſcape them, yet were no accounts of it exiſting, obſervations from all parts of the globe would infer it. The Deluge was not ſo trivial an

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occurrence as to leave no laſting impreſſion upon Nature; but though forgotten by the ſons of men, and only one authentic account remaining concerning it (though many alluſions or hints may be traced in early ages which are and muſt be referred to it), yet has numerous witneſſes demonſtrating the fact at this very day.

It is probable, that not all the tops of preſent mountains were mountain tops before the deluge; they might be level as other lands, they might be low as the reſervoir of waters; for amid the confuſion attending that dreadful cataſtrophe, ſcarce any ſuppoſition of devaſtation can equal the truth.

That I may ſomewhat more orderly ſuggeſt what ideas ſtrike me on this ſubject, I ſhall obſerve (1) that the antediluvian earth had no doubt high hills, and ſeas; but I conceive that its mountains were unequal to the preſent; and, that it had not the ſame proportion of water overflowing its ſurface. I think it had ſeas, but not oceans. And this I argue, from the long lives of its inhabitants, in conſequence of being little affected by alternate moiſture and dryneſs; which implies (what I think likely) the abſence of rain. I conceive the rain of the deluge was the firſt (continued) rain ſeen upon the earth; all previous waterings being performed by dews; and that the rainbow was (and is) conſequently the aerial offspring of clouds raiſed by the evaporating heat of the ſun from the waters of the flood, previous to which event were no receptacles of waters, which (like the preſent ocean) might furniſh the principles of a hurricane, or a tornado. (2) That in ſuch ſeas, lakes, rivers, and other waters, might be immenſe

menſe increaſe of every kind of fiſh. (3) That in conſequence of the deluge, when the fountains of the abyſs were broken up, the beds of ſhells depoſited by ſhell-fiſh, would be in ſome places ſeparated and diſperſed, and borne by the current of riſing waters to other ſpots, where they were not native; alſo, on the other hand, that maſſes of earth would be brought from other ſpots, and depoſited upon ſuch beds of ſhells as might keep their ſituations. In the firſt caſe, the trees and other productions of ſuch grounds would of neceſſity be *under* the beds of ſhells; and when examined by future ages, thoſe which had preſerved their forms, &c. would be found foſſil. The productions of lands brought to ſuch beds of ſhells, would more or leſs mix with them, and after having been ſaturated almoſt to diſſolution with water, would become promiſcuouſly blended, as directed by a thouſand accidents. Thus we ſeem to have accounted for the principal facts belonging to beds of foſſils, wherever found, on plains or mountains.

To account for the elevation of our preſent mountains, we muſt conſider, (1) that there is no neceſſity for ſuppoſing the waters of the deluge were all at equal (*i. e.* extreme) height at the ſame time; but that they felt the influence of the diurnal rotation of the globe, and of its annual circulation, and of the heavenly bodies (and now perhaps firſt commenced extenſive and powerful tides). (2) They ſeem to have rolled over the ſurface of the globe, every where deep enough to deſtroy its inhabitants, yet only at antipodial points capable of covering the mountains. The natural inference is, that at the approach

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of this vaſt body of water, it ſhould root up, deſtroy, and overwhelm; that, when retiring, it ſhould carry away whatever was not ſufficiently ſolid and denſe to reſiſt its fury: thus proceeding to its appointed receptacle (which it now occupies), it muſt needs leave bare many, if not all, places where it had paſſed; and thoſe eminences which had been able to withſtand its power, were now by compariſon greatly heightened. (3) Be it remembered, that as the mountains principally offered impediment to the riſing of this vaſt body of water, they would eſpecially ſuffer from its efforts to over-top them; whereas it would roll over the plains, or any wide-extended champaign, without reſiſtance, and merely damage it, by depoſiting quantities of ſediment brought from elſewhere: of which ſome places might retain but a ſhallow ſurface, through which vegetation might again quickly ſhoot up, and one of theſe places might furniſh the olive branch plucked by the dove. (4) As the motion of the globe is moſt ſenſible at the equator, there would be the greateſt effects from this immenſely powerful tide; there we may expect the higheſt mountains, and correſpondently the greateſt depths of the ſea; and to this agrees obſervation.

The influence of the waters on various parts of our globe, even at this day, is very conſiderable, and the courſe of this influence always attends the diurnal rotation; that is to ſay, the *weſtern* boundaries of an ocean meet its ſtrongeſt impulſe, and are worn away by its continual efforts; here the ſea gains upon the land: whereas, the *eaſtern* boundaries of the ſame ocean are gradually quitted by the waters, become covered

with ſoil, which in time hardens into earth, is added to the ſhore, and here the land gains upon the deep.

But except in the extraordinary and miraculous caſe of the deluge, the operations of water are in common too ſlow, to be conſidered as the only efficient cauſe in formation of mountains: we may juſtly conſider the rapid, the almoſt inſtantaneous effects of fire, as producing more of theſe eminences in a day, when exerted, than water does in an age; and though we have no recent inſtances of mountains raiſed by the force of fire, yet we have accounts ſo very ſimilar, that it ſcarce deſerves the name of imagination in running a parallel.

Thus we have conſidered mountains and rivers; let us now advert a little to their relative importance. It ſeems odd enough at firſt ſight, to affirm that, were there no mountains there would be no rivers; and yet the principle is very fairly deducible; for mountains by their elevation attract the clouds around them, and in a manner force them to depoſit their watery treaſures; they attract them—as they affect the courſes of winds which bring the clouds, and perhaps by their bulk and ſize, as alſo by relative degrees of heat and cold, &c. and when their reſervoirs are filled with rain, they detach ſtreams whoſe union forms rivers. This is remarkably ſeen in rivers which at periodical times overflow their banks; as the Nile, the Gambia, the Ganges, the Burrampooter, and no doubt many others. It is far from an unlikely ſuppoſition, that the mountains in Abyſſinia, which furniſh the Nile and the Niger, are oftentimes clothed with clouds from Europe, perhaps from pretty far north; for the Egyptians gueſs by

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the duration of certain winds, what is likely to be the riſing of their river; and immenſe maſſes of clouds are ſeen croſſing the Mediterranean, at the ſeaſon previous to the Nile's increaſe. Nor is this ſo very wonderful, when we recollect the principles heretofore explained which regulate the trade winds, and monſoons, whoſe influences are, perhaps, in the ſuperior regions of the air, much more extenſive and powerful than we can eaſily imagine or diſcover.

We now ſee one reaſon why at the equator are the largeſt rivers; becauſe, there alſo are the higheſt mountains. Clouds may paſs too high above hills to be checked by ſuch leſſer riſings; but theſe mountains rear their heads above the clouds, and condenſe every vapour around their majeſtic ſummits. It ſhould not paſs unnoticed, that not only in the continents, but alſo in the ſmalleſt iſlands, there are mountains lower or higher; from which lies a gradual, though often imperceptible, deſcent to the ſea. A plain proof of their utility to animal and vegetable life:—in fact, they cannot be ſpared.

Whether or not we may conceive of volcanic phenomena as beneficial or as injurious, we muſt inevitably conſider them as belonging particularly to mountains. Should a volcano open on a plain, it would ſoon elevate the ground about it; after it had ſwelled, and protruded, the earth around its immediate ſeat, it would long continue to augment its bulk, by ſhowers of aſhes, and ſtreams of lava. It is not indeed to be affirmed, that ever a volcano did thus break out; on the contrary, all with which we are acquainted are fed by ſubter-

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raneous fires, and ſituated in mountains; they therefore form a proper article of the preſent diſcourſe.

In treating on the element fire, we obſerved, that its principles were by no means ſparingly diſtributed beneath the ſurface of the globe, but that every ingredient neceſſary in compoſing an *artificial* volcano, was readily found in moſt places that have been examined: ſo that we are under no obligation to recur to a central fire as the parent of natural volcanos; but without going deeper than that ſlight perforation of which man has availed himſelf, we find nothing wanting to furniſh theſe terrific objects. In fact, it is to be noted, that they are diſperſed throughout all parts of the globe; and either actually burn, are ſmothered and dormant, or totally extinct. They may be extinguiſhed by various cauſes, either when their origin lies low, by the waters of the ſea pouring in upon them; or by the filling up of ſome chaſm through which they formerly had acceſs of air; or by conſumption of the bed of burning matter which has ſuſtained them. They are rendered dormant, by having diſcharged that load of heterogeneous principles which could not brook confinement, but whoſe ſtruggles for further extenſion occaſioned an eruption; theſe ſtruggles meeting every where with reſiſtance too powerful for their ſtrength, find at length that the upper part of the mountain which contains them, affords the only paſſage; riſing to this, they boil over the mouth of the volcano in ſtreams of lava. Thus in few words have we related the principles of volcanic eruptions: but to give an adequate idea of their progreſs and effects, exceeds the power of language.

Before an eruption, the ſolid earth is ſhaken by trembling concuſſions; it heaves in agony, as it were, around the mountain's ſeat; vollies of dreadful thunder roll beneath the ground; awful lightnings flaſh from the gloomy mouth; the affrighted ſky is hidden by clouds of intenſe darkneſs; then iſſue tremendous rocks of fire, thrown up amazing heights, and falling in every direction; then a fierce ruddy flame riſing hundreds of fathoms, illuminating ſurrounding objects with gleams of bloody light: to crown the whole, the burning ſummit pours wide-ſpread ſtreams of running lava, or ſome weak part of the mountain's ſide burſts, to afford paſſage to the fiery flood: regardleſs of the toil of induſtry, of the labours of man, it devours all in its progreſs; oppoſition is ineffectual; it riſes over impediments, or conſumes what is meant to confine it. Ill fated Catania! thus the lava of Etna ruſhed upon thee, in one wide ſtream advancing to thy walls; enraged by their oppoſition, it roſe above and poured over them, to thy very centre. Thus were Herculaneum and Pompeii overwhelmed. Quit your habitations, citizens! all is about to ſuffer remedileſs devaſtation. After this deſcription, ſhall it be ſuggeſted that the operations of fire are rather advantageous to the globe, than deſtructive? that by ſub-marine volcanos are freſh iſlands raiſed for the habitations of mankind? that not only the ſmaller ſcale of the Archipelago witneſſes its creative powers, but that evident marks of volcanic origin appear among the newly diſcovered iſlands of the South Sea?

We have many inſtances of iſlands being thus formed in the

the midſt of the ſea, which, though for a long time barren, have afterwards become fruitful ſeats of happineſs and induſtry.

Ancient hiſtorians, and modern travellers, give us ſuch accounts as we can have no room to doubt of. Seneca aſſures us, that in his time the iſland of Theraſia appeared unexpectedly to ſome mariners, as they were employed in another purſuit. Pliny aſſures us, that thirteen iſlands in the Mediterranean appeared at once emerging from the water; the cauſe of which he aſcribes rather to the retiring of the ſea in thoſe parts, than to any ſubterraneous elevation. However, he mentions the iſland of Hiera, near that of Theraſia, as formed by ſubterraneous exploſions; and adds to his liſt ſeveral others, formed in the ſame manner. In one of which he relates that fiſh in great abundance were found, and that all thoſe who ate of them died ſhortly after.

"On the twenty-fourth of May, in the year 1707, a ſlight earthquake was perceived at Santorini; and the day following, at ſun-riſing, an object was ſeen by the inhabitants of that iſland, at two or three miles diſtance at ſea, which appeared like a floating rock. Some perſons, deſirous either of gain, or excited by curioſity, went there, and found, even while they ſtood upon this rock, that it ſeemed to riſe beneath their feet. They perceived alſo that its ſurface was covered with pumice ſtones and oyſters, which it had raiſed from the bottom. Every day after, until the fourteenth of June, this rock ſeemed conſiderably to increaſe; and then was found to be half a mile round, and about thirty feet above the ſea. The earth of which it was compoſed ſeemed whitiſh, with a

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ſmall portion of clay. Soon after this the ſea again appeared troubled, and ſteams aroſe, which were very offenſive to the inhabitants of Santorini. But on the ſixteenth of the ſucceeding month, ſeventeen or eighteen rocks more were ſeen to riſe out of the ſea, and at length to join together. All this was accompanied with the moſt terrible noiſe, and fires which proceeded from the iſland that was newly formed. The whole maſs, however, of all this new-formed earth, uniting, encreaſed every day, both in height and breadth, and by the force of its exploſions, caſt forth rocks to ſeven miles diſtance. This continued to bear the ſame dreadful appearances till the month of November in the ſame year; and it is at preſent a volcano which ſometimes renews its exploſions. It is about three miles in circumference; and more than from thirty-five to forty feet high."

It ſeems extraordinary, that about this place in particular, iſlands have appeared at different times, particularly that of Hiera, mentioned above, which has received conſiderable additions in ſucceeding ages. Juſtin tells us, that at the time the Macedonians were at war with the Romans, a new iſland appeared between thoſe of Theramenes and Theraſia, by means of an earthquake. We are told, that this became half as big again about a thouſand years after; another iſland riſing up by its ſide, and joining to it, ſo as ſcarce at preſent to be diſtinguiſhed from the former.

A new iſland was formed, in the year 1720, near that of Tercera, near the continent of Africa, by the ſame cauſes. In the beginning of December, at night, there was a terrible

earthquake at that place, and the top of a new iſland appeared, which caſt forth ſmoke in vaſt quantities. The pilot of a ſhip, who approached it, ſounded on one ſide of this iſland, and could not find ground at ſixty fathom. At the other ſide the ſea was totally tinged of a different colour, exhibiting a mixture of white, blue, and green; and was very ſhallow. This iſland, on its firſt appearance, was larger than it is at preſent; for it has, ſince that time, ſunk in ſuch a manner, as to be ſcarce above water.

A traveller, whom theſe appearances could not avoid affecting, ſpeaks of them in this manner: "What can be more ſurpriſing than to ſee fire not only break out of the bowels of the earth, but alſo to make itſelf a paſſage through the waters of the ſea! What can be more extraordinary or foreign to our common notions of things, than to ſee the bottom of the ſea riſe up into a mountain above the water, and become ſo firm an iſland as to be able to reſiſt the violence of the greateſt ſtorms! I know that ſubterraneous fires, when pent in a narrow paſſage, are able to raiſe up a maſs of earth as large as an iſland. But that this ſhould be done in ſo regular and exact a manner, that the water of the ſea ſhould not be able to penetrate and extinguiſh thoſe fires; that, after having made ſo many paſſages, they ſhould retain force enough to raiſe the earth; and, in fine, after having been extinguiſhed, that the maſs of earth ſhould not fall down, or ſink again with its own weight, but ſtill remain in a manner ſuſpended over the great arch below! This is what to me ſeems more ſurpriſing

than any thing that has been related of Mount Ætna, Veſuvius, or any other volcano."

Sir Wm. Hamilton, in his reſearches among the volcanic iſlands around Sicily, is of opinion, that they alſo owe their origin to ſubterraneous fires; and indeed he thinks, that though volcanos may deſtroy what is more immediately within their reach, yet, on the whole, they are beneficial and creative.

Such is the effect of fires which proceed from the more inward receſſes of the earth. Mr. Buffon, indeed, ſuppoſes them rooted but very little below the beds of mountains. But the contrary ſeems demonſtrated by a well-known fact; namely, that the quantity of matter diſcharged from Ætna alone, is computed to exceed twenty times the bulk of the mountain. The greateſt part of Sicily ſeems covered with its lava. The inhabitants of Catanea have found, at the diſtance of ſeveral miles, ſtreets and houſes, ſixty feet deep, overwhelmed by lava; the walls of theſe very houſes being built of materials evidently thrown up by the mountain. The inference is obvious; this matter thus exploded cannot belong to the mountain itſelf, it would have been quickly conſumed; it cannot be derived from a moderate depth, ſince its amazing quantity evinces, that all around the bottom muſt have long ſince been exhauſted.

By way of contraſt to what we have been relating, I wiſh to remind my auditory, that mountains are alſo the ſeats of eternal ſnow and relentleſs froſt: by a ſtrange combination, their internal parts are the reſidences of flames and fire; their external

external and ſuperior parts are cold as the frozen zone. For as volcanic eruptions are only at intervals, theſe mountains, in common with others, are ſubjected to atmoſpheric viciſſitudes, and covered with the burdens of the clouds.

The moſt intereſting ſpectacles of this kind, are thoſe valleys of ſnow ſituated among the mountains of Switzerland, with which being beſt acquainted we are moſt impreſſed. Every mountain around is ſnow, from where we ſtand, to thoſe by diſtance tinged a ſolid blue, rearing their dreary ſummits to the clouds; the valleys beneath and between them, are one vaſt bed of ice and ſnow, broken into a thouſand fantaſtic forms. Here, ſeeming ſmooth ſheets of glittering white; there, riſing into waves of ſnow; interſected here by channels of tremendous depth, narrow and ſteep; there, ſeparated by wider breaches. Let none preſume that he has but to go ſtrait to his propoſed object, ever and anon, will he find new impediments. The frozen ridges will be too perpendicular to climb, or the (apparently) ſmall cracks and fiſſures will be far too wide to be paſſed in ſafety; he muſt go round, on one ſide, on the other, and think himſelf lucky, if in advancing one mile, he walk only four.—Such are the Glacieres.

The inhabitants of the valleys around theſe Glacieres, paſs their crevices by means of a long pole tied to another, which is held by a companion; this they lay croſs the opening; if the ſnow on each bank is firm, the firſt adventurer gets ſafely over, and aſſiſts his friend; if it gives way, he would inevitably fall eighty or an hundred fathoms deep, were he not prevented

vented by the rope which unites the two poles. To ſuch riſques are they accuſtomed, till they learn to deſpiſe them. It is enquired, how theſe glacières originated, and whether they increaſe. Doubtleſs they were formed by ſnows remaining throughout the year, in ſpite of ſummer ſuns, and augmented by returning winter; but it is probable they ſcarce increaſe now, ſince much of their waters ſupply the rivers which riſe from theſe mountains; as the Rhone and the Danube, to name no others, which commencing here their courſes, run contrary ways to their diſcharges; thereby proving this territory to be the higheſt land in Europe.

There is nothing more dreadful than the united violence of the two principles which have now engaged our attention: a very diſtreſſing inſtance we have in the following account of Don Antonio da Ulloa.

The mountain of Cotopaxi, as deſcribed by Ulloa, is more than three miles perpendicular from the ſea; and it became a volcano at the time of the Spaniards' firſt arrival in that country. A new eruption of it happened in the year 1743, having been ſome days preceded by a continual roaring in its bowels. The ſound of one of theſe mountains is not like that of the volcanos in Europe, confined to a province, but is heard at an hundred and fifty miles diſtance. "An aperture was made in the ſummit of this immenſe mountain; and three more about equal heights, near the middle of its declivity, which was at that time buried under prodigious maſſes of ſnow. The ignited ſubſtances ejected on that occaſion, mixed with a prodigious quantity of ice and ſnow, melting amidſt

amidſt the flames, were carried down with ſuch aſtoniſhing rapidity, that in an inſtant the valley from Callo to Latacunga was overflowed; and beſides its ravages in bearing down the houſes of the Indians, and other poor inhabitants, great numbers of people loſt their lives. The river of Latacunga was the channel of this terrible flood; till being too ſmall for receiving ſuch a prodigious current, it overflowed the adjacent country, like a vaſt lake, near the town, and carried away all the buildings within its reach. The inhabitants retired to a ſpot of higher ground behind the town, of which thoſe parts which ſtood within the limits of the current were totally deſtroyed. The dread of ſtill greater devaſtations did not ſubſide for three days; during which the volcano ejected cinders, while torrents of melted ice and ſnow poured down its ſides. The eruption laſted ſeveral days, and was accompanied with terrible roarings of the wind, ruſhing through the volcano ſtill louder than the former rumblings in its bowels. At laſt all was quiet, neither fire nor ſmoke to be ſeen, nor noiſe to be heard; till, in the enſuing year, the flames again appeared with recruited violence, forcing their paſſage through ſeveral other parts of the mountain, ſo that in clear nights the flames being reflected by the tranſparent ice, formed an awfully magnificent illumination."

Volcanic mountains are diſtributed all over the globe; wherever we obſerve we trace them; from Hecla in Iceland (the moſt northern we know), to thoſe of warmer climates, Veſuvius, Strombolo, and Ætna; thoſe beneath the tropics, not in America only, but alſo in the Phillipine iſlands; at,

and

and around Otaheite; and ſouth to Terra del Fuego. Mountains of ſnow are alſo general; thus many tracts of land, in all climates, are kept aloof from mankind: whether to ſeclude from the prying eye of curioſity the greater operations of nature, or whether as inſtruments of correction to mankind, we know not: but while Providence thus clothes with terrors theſe barren and deſolate mountains, or rather, perhaps, while theſe barren and deſolate mountains, naturally the reſidence of terrors, are forced to contribute that ſhare to the general welfare, of which leſſer elevations are incapable, let us gratefully remember the contraſt between them and our favourite reſidences (hills); theſe, though leſs lofty, leſs majeſtic, leſs ſolemn, are infinitely more pleaſing, more ſalubrious, more fertile; here we feel the pleaſures of exiſtence, here we breathe purer air, we enjoy ſurrounding proſpects, delighted with their diverſity and extent; and here, whatever, in vegetable fertility and luxuriant herbage, may refreſh or ſupport us, we enjoy without anxiety, and cultivate without apprehenſion.

I have often wondered how the inhabitants of Veſuvius could live in any kind of comfort, knowing that immediately beneath them are beds of dreadful combuſtibles: yet moſt of Veſuvius is cultivated (and from its grapes are made rich and delicious wines);—ſo greatly does intimacy with danger leſſen apprehenſion of it! It is, nevertheleſs, a pleaſing reflection, that the labour we beſtow has a proſpect of permanence; that for years to come we may enjoy the fruit of preſent exertions; a reflection to which a Veſuvian is a ſtranger;

who, though he labour in planting his vines, is uncertain whether he ſhall taſte their produce, or ſhall ſee them conſumed by volcanic eruptions. Such kind of forecaſt and reaſoning is in foreign climates thought *right-down* Engliſh :— be it ſo; let them, if they pleaſe, paſs to-day, without conſideration of the morrow, ſince why ſhould they eſtimate what is ſo precarious? Ever may it be the happineſs of this favoured iſland, that the ſecurity of time preſent extends alſo to time future, and that to calculate for diſtant periods is but reaſoning from paſt experience, is but ſuppoſing the continuation of what we have been accuſtomed to enjoy, at once regular, animating, and natural.

LECTURE

LECTURE II.

LADIES and GENTLEMEN,

WE have hitherto examined merely the ſuperficial appearance of our globe, as it ſtrikes the view of a diſtant ſpectator: We propoſe now, as it were, to alight upon it, and explore ſomewhat more intimately its ſtructure and its receſſes. I might, indeed, add much to what I have already ſaid, in tracing a gradation from mountains to hills, and from rivers to rivulets; or, following a ſtream from its origin to its termination, I might point out its adventures (ſo to expreſs myſelf), winding now gentle and ſerene in one clear unruffled progreſs, divided elſewhere by numerous iſlands; ſometimes oppoſed by jutting rocks, and falling in tremendous agitation to unknown depths; or ſinking beneath the earth, and continuing its progreſs ſecluded from obſervation; perhaps, after an interval of many miles, riſing again to light; not gradually, as a fountain, but ſuddenly, as a river. Moſt of theſe inſtances our own country affords, nor are they infrequent throughout the globe.

Thoſe circumſtances, thus hinted, juſt to enliven your recollection, I ſhall advert to what, perhaps, ſhould have been formerly noticed---the *proportion* of land and water appointed

to

to our habitation. Thoſe who have attended to this, inform us, that the ſea has three times the ſurface of the land; and Dr. LONG mentions, his taking the paper of a terreſtrial globe, and ſeparating the land from the water; the weight of the paper repreſenting the ſea was 349 grains, that of the land 124 grains, which ſeems to be near enough the truth.

In ſo great a proportion of the earth's ſurface, covered by water, we may well ſuppoſe, are contained an infinite variety of particularities, of which we are totally ignorant, and to which our acquaintance never will extend. Obliged, therefore, to form a judgment of what is beyond us, by what has undergone examination, we wiſh you not to conceive of the bottom of the ſea as one uninterrupted waſte; but, though great part, like African deſerts, may deſerve that deſcription, yet elſewhere it has its verdant plains, its foreſts, its trees, its plants, and theſe have their inhabitants of various forms, properties, and degrees of life. Thus in much of the ſea around the Weſt-India iſlands, it is not uncommon, in clear weather, to ſee the bottom, its herbage, and the turtle feeding upon it. And in our own northern ſeas, many branches (apparently broken off from large trees) of as real wood as grows upon land, have occaſionally been gathered from the deep. The ſequel of theſe remarks will appear hereafter.

The deeper we dive (or examine, by any method) into the ſea, the *colder* we find its temperature: this is verified by obſervation; for when a very great length of line is let down, the weight at the bottom of it, and the line itſelf, near its bottom,

bottom, come up as cold as ice; and this, whether the line has really reached the ſubmarine earth or not: indeed, in this particular, we are liable to deception from various cauſes; and in ſounding very great depths, are ſeldom certain in pronouncing them *unfathomable.* For, (1) The denſity of the water naturally increaſes as it advances to the center; ſo that a weight, however ſkilfully conſtructed or directed, muſt of neceſſity advance perpetually into a medium more ſimilar to itſelf. (2.) The line, uſed in theſe experiments, is of a buoyant nature; in conſequence, the greater length of line is uſed, the greater power is exerted counter-active of the weight; ſo that, after all poſſible efforts, the weight may reach within a little ſpace of the bottom, yet no ſuch effect appear when examined. (3.) It is impoſſible to determine what currents are at the bottom of the ſea; but it is evident their velocity muſt have its effect upon any body immerged in them; and ſhould they bear that body conſiderably out of the perpendicular, it may have no perceivable effect on the upper part of ſo great length of line as is ſometimes employed; eſpecially, if that part be in ſtill water. Circumſcribed, therefore, by theſe impediments, in our ſubmarine reſearches, we admit, that many parts of the ſea are juſtly deemed *unfathomable,* but are not, therefore, *bottomleſs.*

We have alſo on land many holes and caverns, which have the reputation of being unfathomable: I am not, indeed, certain that experiments have been ſo often applied to theſe, as to many parts of the ſea; becauſe no benefit, equal to what navigation expects from accurate knowledge of marine depths,

depths, can poſſibly reſult from ſuch inquiries; but that philoſophical curioſity has occaſionally engaged itſelf in ſuch attempts, though to little purpoſe, is certain.

Of this kind is that cavern called Elden-hole, in Derbyſhire; which, Dr. Plot tells us, was ſounded by a line of 2,800 feet, without finding the bottom, or meeting with water: yet its mouth at the top is not above forty yards over. This immeaſurable cavern runs perpendicularly downward; and its ſides ſeem to *tally* ſo plainly as to ſhew that they once were united. Thoſe who viſit the place, generally procure ſtones to be thrown into its mouth; theſe are heard for ſeveral minutes, falling and ſtriking againſt the ſides of the cavern, producing a ſound that reſembles diſtant thunder, dying away as the ſtone goes deeper.

Nature ſeems to have thought, that no inhabitants of the globe were entitled to penetrate beyond the ſuperficies, or would ſo far preſume to overpaſs their limits as to inquire into tranſactions of the chambers of darkneſs: having made ample proviſion for their well-being in regions ſuited to their properties and talents, why ſhould they explore the receſſes of her domain, and pry into what ſhe had ſedulouſly concealed? But that ſomewhat might be found to gratify curioſity, or to offer occaſional utility, here and there ſhe preſents us *caverns*, or excavations, whoſe properties may hint at what paſſes beyond our penetration; and very frequently ſhe offers *fiſſures*, or cracks of earth, which diſcover a little of the nature of that compoſition we inhabit: theſe fiſſures may be conſidered merely as enlarged ideas of ſuch as appear after a ſeries of dry weather,

in our cultivated fields; but muſt be very greatly augmented in dimenſions, from ſuch humble crevices, to thoſe whoſe ſides are many hundred yards aſunder. As we learn little from theſe which is not acquired elſewhere, we only now hint at their univerſality, though often (perhaps moſtly) concealed; being filled up by adventitious earth, gravel, &c. in the courſe of years, to a level with the ſurface around them.

But as the natural openings, we call caverns, have ſundry peculiarities attending them, they will engage ſomewhat more of our attention. It ſhould ſeem, that few of them are entirely without water, more or leſs, paſſing through them; ſometimes trickling by crannies, ſometimes diſcharging itſelf by a river: alſo, that the proceſs of *petrifaction* is uſually ſeen to moſt advantage in theſe under-ground receſſes; this implies the operation of water; and as this water evidently has run through beds of ſtrata (whoſe particles being abraded by it, are brought with it), it ſupports the prevailing hypotheſis of the origin of rivers, already noticed. Stony matter may be conceived as a compoſition of innumerable ſmall and minute particles, making a ſolid body. Petrifaction, in the caſe of foſſils, is the *ſubſtitution* of this ſtony matter, in lieu of that compoſing the body becoming foſſil: in the caſe of ſpars, and ſparry incruſtations, it is merely a *depoſition* of this ſame matter in the firſt convenient receptacle. The formation of an icicle ſeems illuſtratory of the ſubject: as the water dripping from the eaves of a houſe is congealed in its deſcent, it adheres *depending* from ſuch eaves (in which ſituation it is augmented, by freſh drops of water joining it, on all ſides,

and alſo lengthening it); or falling, it is on the ground enlarged by ſucceſſive additions of freezing water. We have only to ſuppoſe, water ſaturated with gritty matter which it quits, to account for ſimilar petrifaction. As to the diverſified and often highly beautiful colours of ſpars, &c. they are no difficulty, when we conſider the various tinging powers of particles of iron, clay, &c. through beds of which the water may have paſſed. From theſe principles we infer, that water ſeems to have had the greateſt and moſt general ſhare in forming theſe cavities, eſpecially where they are of conſiderable extent; but, as in ſome inſtances, they are found not only *between* rocks, but alſo *inſide* ſuch obdurate matter, croſſing them, in their ſtrongeſt parts, and correſponding ſide to ſide with much accuracy; we muſt, in theſe caſes, conſider the force of earthquakes as their cauſe, if deep beneath the ground: if ſuperficial, froſts, and the expanſion of congealed water, whoſe efforts are irreſiſtible:—thus far nature may have formed them; but that they are often finiſhed by the hand of man is very ſuppoſable. Man may have rendered their entrances leſs rugged, their apartments leſs confined, may have *trimmed* their projecting points, and imparted what of ſmoothneſs they poſſeſs. Moreover, by tracing their windings, and examining their contents, man has diſcovered many articles, in which he finds, or imagines, no little value: deſirous of durability in his edifices, he employs ſtone in their erection; and, forgetting that a tree was his natural habitation, he exchanges timber for the productions of the quarry: from hence, alſo, he procures ſlate, coals, ſalt, metals of many kinds,

gems

gems of various colours, and, in ſhort, ſo great a proportion of what he deems neceſſaries, that (excluſive of grain) it may bear a query, whether he is moſt indebted to the exterior or interior productions of the globe, for what he calls the conveniences of life!

The nature of MINES is very different, according to that of the mineral they contain. It is not always that indications of mines appear on the ſurface, and it is ſeldom that a diſtrict where mines abound is fertile: whether the exhalations from ſuch beds of minerals is deſtructive or repulſive to vegetation; whether they are ſo ſituated as to invite no effort of cultivation: however it be, the moſt conſiderable mines are uſually ſurrounded by a barren country.

I ſhall juſt hint a few words on the ſeveral ſorts of mines, beginning with what we eſteem the moſt precious metals.

GOLD is always found in hot countries; whence ſome imagine the ſun has great ſhare in its production, or perfection. Let us hear the accounts of thoſe who have viſited them. Mines of gold and ſilver were formerly worked in England; but the plenty imported into Europe has rendered the expence of working our own greater than the profit. Africa yields plenty of gold, which is generally brought down by the rivers. China has alſo much gold. In Mexico gold is found either in grains, in duſt, in the ſands of rivers, or in ſtone in the mines. The *grains* are like ſeeds or kernels of fruit, without mixture of other metal, and have no need of refining. ACOSTA aſſures us, he had ſeen theſe ſo large as to weigh many pounds; ſometimes they find pieces very fine and pure,

like ſmall round roots. But much the greateſt quantity of gold is found in *duſt* in the ſands of rivers and torrents, after great rains: it is the buſineſs of many thouſand Indians and negroes to take up and waſh ſuch ſands, in bowls and baſons, till they have ſeparated the gold from the ſand. Gold which is found in the mines, is intermixed, and in a manner incorporated, with great hard ſtones; ſome of which, the ſame writer relates, he has ſeen, that were half gold and half ſtone: it runs in veins like ſilver, and is exceedingly hard to dig and ſeparate: this gold is uſually mixed with ſilver or copper; that which is incorporated with copper is the beſt.

Gold ſeems to lie much nearer the ſurface than ſilver, being found in large pieces at the roots of trees on the mountains; and waſhed into the rivers by the rains; and, it is ſaid, if they do not find it pretty near the ſurface in the mines, they never dig ſo deep for it as they do for ſilver.

Gold is more eſteemed than any other metal, ACOSTA obſerves, becauſe moſt durable and incorruptible; for fire, which conſumes and diminiſhes other metals, brings this to perfection. Gold keeps its colour though often paſſed through the fire; and, notwithſtanding the body is ſo firm and ſolid, yet it is the moſt ſoft and malleable, and moſt eaſily wrought of all metals.

It ſhould ſeem by this relation, that there are few gold *mines*, as we underſtand the term; this metal hitherto having been procured rather from the ſuperficial, than the deeper parts of the globe.

SILVER

SILVER MINES are uſually found in barren rocks and mountains, though ſometimes in plains. There are two ſorts, one ſtraggling, in ſpots; the other more contiguous; this has the greateſt depth and length, and is ſaid to reſemble branches and ramifications of trees and plants: where they find one, they uſually meet with many.

The veins of ſilver run between two rocks; one commonly hard as flint, the other ſofter. The ore is very unequal; for in the ſame vein they find very rich and very poor; the richeſt ore is amber coloured, the ſecond ſort inclines to black, a third is red, a fourth of an aſh colour; and ſome of the ore is ſcarce to be diſtinguiſhed from common ſtone, unleſs by thoſe well ſkilled in minerals.

GEMELLI CARERI relates, that at Mexico, A. D. 1698, he viſited the ſilver mines of Pachuca; one of which, called Santa Cruz, was 224 Engliſh yards deep; the other, called Navarro, was 195 yards deep. Out of the firſt, the ore was drawn up by wheels kept in motion by four mules. Out of the mine Navarro, the Indians brought up the ore on their backs, with imminent danger, climbing up many ladders, or rather, upright poſts with notches in them. On a neighbouring mountain, he found, in a little city of thatched houſes, not leſs than 12,000 Indian miners; adding, that within ſix leagues of that mountain are a thouſand mines; and that in one, called the Trinity, nine hundred or a thouſand men are employed. It is common with the Spaniards of Mexico and Peru, to dig mountains perfectly hollow, in ſearch of

ſilver,

ſilver, and leave nothing but a cruſt of earth and rock, which requires no ſmall ſkill and labour to ſupport, till they have exhauſted the treaſure.

Our author ſays, he had the curioſity to enter a mine, to ſee the veins of ſilver; he was aſtoniſhed to ſee how likely the mine was to tumble in, and would have re-aſcended, but his guide, who carried a light, perſuaded him to venture down the reſt; which he did, in great fear, becauſe he found it difficult ſometimes to claſp in his arms the poſt in which the ſteps were cut, and fix his feet in the notches. When at the bottom, he began to reflect on the danger, not only of being overwhelmed, but of peſtilential damps that frequent theſe diſmal caverns. After a ſtay of two hours, he went up again in the utmoſt terror; and when got into the open air, he ſeemed newly born into the world.

The ſilver mines of Potoſi, in Peru, are the richeſt in the world. Theſe were diſcovered A. D. 1545, about fourteen years after the Spaniards invaded that country. The mountain containing the ſilver is entirely undermined, ſuch vaſt quantities having been drawn from it. It is in form like a ſugar-loaf, of a dark red colour, a league in circumference at bottom, and a quarter of a league toward the top, and ſtands in a plain. It is ſome mornings covered with a cap of ſnow: never was ſeen a more barren country for ſeveral miles round.

Acosta relates that they were diſcovered by accident. He ſays, an Indian, purſuing his game up the mountain of Potoſi, and being like to fall, to ſave himſelf, laid hold of a

ſhrub

ſhrub that grew upon a vein of ſilver; happening to pull it up by the roots, he diſcovered the rich metal underneath. He kept the ſecret, it ſeems, till he had procured ſilver enough to enrich himſelf and family; but at length it was diſcovered.

ACOSTA informs us, that the firſt forty years theſe mines were wrought, there were regiſtered two thouſand one hundred millions of pieces of eight (or crowns), beſides a great deal carried off without paying cuſtom. He ſays, this rock of Potoſi contained four principal veins, all on the eaſt of the mountain, toward the riſing ſun. The veins run from north to ſouth, the largeſt being ſix feet over, and the narroweſt about a ſpan: other ramifications branched out like boughs of trees; in the richeſt of theſe veins were ſeventy-eight mines, eighty or an hundred fathom deep, and ſome two hundred. At length, inſtead of digging downwards, they opened the rock at bottom, and proceeded horizontally, till they met with the ſilver veins: but, he obſerves, the nearer a vein is to the ſurface of the earth, the richer it is. He ſays, the rock was ſo hard, that they worked between twenty and thirty years in the principal opening, before they came at the metal. The air is ſo cold and unwholeſome, that a perſon, at his firſt entrance, is ſeized with a diſorder not unlike ſea-ſickneſs; as our author himſelf experienced.

I have ſeen accounts which have attributed to labour in the mines the moſt infamous of diſorders; but though this be falſe, it proves their reputation for infalubrity. However,

in this reſpect, I think they cannot exceed, if they can equal, what is related of our European quickſilver mines.

At thoſe near the village of Idra, in Hungary, nothing can adequately deſcribe the deplorable infirmities of ſuch as fill the hoſpital: emaciated and crippled, every limb contracted and convulſed, and ſome almoſt tranſpiring quickſilver at every pore. There was one man, ſays Dr. Pope, who was not in the mines above half a year, yet whoſe body was ſo impregnated with this mineral, that putting a piece of braſs money in his mouth, or rubbing it between his fingers, it immediately became as white as if waſhed over with quickſilver. In this manner all the workmen are killed, ſooner or later; firſt becoming paralytic, then dying conſumptive: and this for---ſeven-pence a day!

Quickſilver is found after different manners, ſometimes incloſed in its own mineral, ſometimes fluid, ſometimes among earth and ſtones, and often, embodied in natural cinnabar.

LEAD ore always yields a portion of ſilver; and the pooreſt lead often yields the moſt ſilver; hence, many of our furnaces are enabled to maintain themſelves; though their ore of lead be inferior. It is ſaid, that, from the ſilver furniſhed by ſuch works, Sir HUGH MIDDLETON was enabled to execute that moſt important undertaking, the New-River at London.

All metals, indeed, are, more or leſs, mixed with each other; COPPER, TIN, &c. (whoſe mines may eaſily be conceived of after what has been ſaid) are united with other minerals.

There are many kinds of minerals, known only on the ſpot where they are found; or, if exported to foreign parts,

are ſo tranſmuted by the proceſſes they have undergone, as little to reſemble their native ſtate.

In our own country we have moſt kinds of metals; and yet, perhaps, that, which though a mineral, is no metal, is our moſt uſeful production; I mean COAL, which ſeems diſpoſed in one vaſt bed under moſt part of England. A coal mine is a combination of ſubterraneous galleries, winding in various directions and ſlopes, according to the bias of a vein, and carried forward, or ſunk deeper, according to circumſtances: the deepeſt are thought to be about 1,000 to 1,200 yards perpendicular depth. (I think I recollect reading of one which extended *under* the bed of the ſea, in that place: eventually, to its ruin by the waters). In proper places are left great pillars of the mineral for ſupport, and the galleries are ſo narrow, as barely to afford paſſage; but theſe are not their greateſt evils, nor thoſe of mines in general; the vapours with which they abound are little conceivable by thoſe who have not viſited them; though ſome chemical combinations ſeem greatly ſimilar.

Sometimes theſe noxious vapours are perceived by their delightful fragrance, reſembling that of the pea-bloſſom, from whence this kind of damp has its name. This flattering ſcent does not deceive the miners; but having timely notice of its approach, they avoid it: it continues, generally, during the ſummer. The approach of another kind of damp, is indicated by the burning of the candles, which ſeem to collect their flame into a globe of light, and thus gradually leſſen, till quite extinguiſhed: from this alſo the miners frequently eſcape; ſuch

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as have the misfortune to be caught in it, either ſwoon away, and are ſuffocated, or ſlowly recover in exceſſive agonies. A third, called the fulminating damp, much more dangerous than either of the former, ſtrikes down all before it, like a flaſh of gunpowder, giving no warning. But the moſt dangerous is found in places where the vapour has been long confined, and is by ſome accident ſet free. This air ruſhing out from thence is fatal; ſcarce any eſcape the deſtruction attending it.

The air of many mines is ſeemingly no way prejudicial to health, but permits the workmen to breathe freely; and yet in theſe, if a lighted candle be introduced, they immediately take fire, and their whole cavern becomes one furnace of flame. In mines, therefore, ſubject to damps of this kind, they are obliged to have recourſe to a very peculiar contrivance to ſupply ſufficient light for their operations. This is by a great wheel; the circumference of which is beſet with flints, which ſtriking againſt ſteels, placed for that purpoſe, at the extremity, a ſtream of fire is produced, which affords light enough; yet, does not ſet fire to the mineral vapour. Of this kind are the mines about Briſtol; on the contrary, in other mines, a ſingle ſpark ſtruck out from the colliſion of flint and ſteel, would ſet the whole ſhaft in a flame. In ſuch, therefore, every precaution is uſed to avoid a colliſion; the workmen making uſe only of wooden inſtruments in digging; and being cautious before they enter the mine, to take out even the nails from their ſhoes.

DIAMONDS do not lie in clusters, in their mines, but dispersed, so that often they occasion much disappointment, with little amends. A story is related which seems very characteristic both of them and their adventurers.

A Portuguese went from Goa to a diamond mine at Currure, in India; having spent in mining all he had, even to his clothes, while the miners were at work, for the last day's expence, he prepared a cup of poison, resolving, if that night he found nothing, to drink his last, with the conclusion of his money; but in the evening, the workmen brought him a very fair-spread stone, of twenty pagos weight; in commemoration whereof, he caused a great stone to be erected in the place, with an inscription engraven on it, in the Hindoos or Tellingda tongue, to the following effect, which still remains.

Your wife and children sell, sell all you have,
Nor spare your clothes, nay make yourself a slave;
And money raise: then to Currure make haste,
And search the mines, you'll find a prize at last.

What think my fair friends of the sentiment contained in these verses of the diamond seeker? It is indeed somewhat too openly expressed, to engage our applause; but, by how many, who *will* be rich, is the principle covertly adopted, to the injury of their families, if not to the preparation of poison for themselves!

I shall notice another kind of mine, different from any yet mentioned, which, instead of being hot, is cold, and, instead

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of preſenting a gloomy cavern, is ſo reſplendent when enlightened, as to form a magnificent ſpectacle: for ſuch is the account given us of the SALT MINES, whoſe ſparkling whiteneſs is highly brilliant. We are told of a ſalt mine in Poland, ſo capacious, as to have in it a town, with ten thouſand inhabitants, not omitting handſome reſidences for officers, and churches for worſhip. Moreover, if I remember right, through this prodigious rock of ſalt runs a *freſh-water river*, and ſo compact and hard is the mineral, its bed, as in no wiſe to diminiſh its freſhneſs.

All productions of the quarry, marbles of various beauty, colours, and properties; ſtones of various hardneſs, and immenſe bulk; marle, lime, chalk, &c. are ſo many extractions from beneath the ſurface of the earth.

Enough of mines for the preſent; thoſe riches whoſe reſidence is in the breaſt—how little are they augmented by theſe denominated valuables! How little are terreſtrial riches capable of enriching! The labourer in Potoſi toils not for himſelf, but for Europe; and more of his gold arrives in London, than he retains around its native mine—it viſits the artizan at the loom, and the huſbandman in the field. Avarice itſelf muſt relinquiſh its treaſures for food and clothing.

We obſerved, that deſcending into the great deep, we found the cold *increaſing* as we quitted the ſurface; but deſcending into a mine, after the chill of the firſt entry is over, the heat is perceived to *increaſe*, ſo that thoſe who labour at great depths, uſually ſtrip themſelves nearly naked. Whether this heat is the reſult of an approach to the central ſeat of fire,

or to any volcanic branches; or whether it reſult from the principles of fire, ſcattered, though not exerted, among the minerals; or whether it be ſimply a conſequence of the cloſeneſs of ſuch places, and their want of refrigeration by renewals of freſh air, has been doubted. That air, when confined, is ſoon heated and polluted, needs no proof; that among ſo many ſteams and vapours, increaſed by the atmoſphere of a perſon's own body, the air ſhould be heated, or damaged, is not wonderful; and this ſeems quite as probable to be the cauſe of ſubterraneous heat, as ſo very ſmall an approach toward central principles, whatever they may be. For, after all our reſearches into the body of the globe, we have little knowledge of its real ſtructure; our utmoſt efforts equal not his exertions, who ſhould cut *half way* through the rind of an orange; yet how little were ſuch an one qualified to determine its interior! If he ſhould gueſs right as to its diviſions and its kernels, by what authority ſhould his gueſſes be juſtified? But that he ſhould rather miſtake than ſucceed, were thouſands to one againſt him.

So far as we have penetrated, the earth ſeems compoſed of various layers, or beds of matters, ranged (generally) the heavier beneath, and the lighter above. This is not every where the caſe, yet the exceptions to this principle ſeem not ſufficient to abrogate it. The increaſe of theſe beds in denſity, ſeems analogous to the general principles of gravitation, and to what may be thought the moſt natural conſtruction of ſo great a body: ſince ſuch we find the atmoſphere and the ocean, why not, alſo, the ſolid of the globe?

In general, the uppermoſt layer is that coat of blackiſh mold, which is called, by ſome, garden earth. This ſeems compoſed of animal and vegetable bodies decayed, as we have formerly hinted. This earth, however, is not pure, but mixed with much ſtony and gravelly matter, from the layers immediately beneath it. It generally happens, that the ſoil is fertile in proportion to the quantity of this putrified mold to its mixture of gravel.

Deſcending from this external ſurface is found gravel or ſand, then clay or marle, then chalk or coal, marbles, ores, ſands, gravels, in ſucceſſive alternation, each more denſe as ſituated deeper. The clay, for inſtance, found at the depth of an hundred feet, is uſually heavier than that near the ſurface. In a well dug at Amſterdam, to the depth of two hundred and thirty feet, the following ſubſtances were found in ſucceſſion: ſeven feet of vegetable earth, nine of turf, nine of ſoft clay, eight of ſand, four of earth, ten of clay, four of earth, ten of ſand, two of clay, four of white ſand, one of ſoft earth, fourteen of ſand, eight of clay mixed with ſand, four of ſea-ſand mixed with ſhells, then an hundred and two feet of ſoft clay, and then thirty-one feet of ſand. Elſewhere theſe proportions vary, and, indeed, are ſeldom the ſame in any two places, or to any conſiderable extent.

Thus the earth is compoſed of beds over beds; each, ſo far as it extends, always maintaining the ſame thickneſs. As we proceed to conſiderable depths, we find each layer grow thicker. Theſe layers are ſometimes very extenſive, ſome leagues

leagues in circumference; but not uniformly continued over the globe.

What further notice we receive of the compoſition of the earth at ſtill greater depths, is chiefly through the very ſuſpicious medium of volcanos. This is ſuſpicious, becauſe, in whatever form, or poſſeſſing whatever properties, the matters thrown up by theſe dreadful phænomena might originally become part of them, in their deep receſſes; it is natural to conclude, that the force of the fires they have ſuffered, has changed them, partially at leaſt, if not totally, depriving them of ſome principles, and communicating others.

The regularity of the layers of earth, in all places which have been examined, has induced many perſons to think, that time was, when the whole ſuperficial maſs of earth was a kind of pulp or jelly, which gradually depoſiting the groſſer particles with which it was loaded, the heavier naturally ſunk deepeſt, while the lighter almoſt floated. It might be ſo, in great meaſure, and in many places; yet, I think, where immenſe mountains, with vaſt chaſms between them, are totally bare of earth, and exhibit one uniform body of granite (as the Alps do), or any equally hard ſtone, *they muſt* be excluded from this idea: and I think it ſeems indeterminate where quarries are ſuperficial. Though I am well aware that many kinds of ſtone have demonſtrative evidence that once they were in a pulpy ſtate, and are become hard by the quittance of their water: ſuch evidence are the foſſil bodies they contain (often in great numbers), and which have a very curious appearance when ſuch ſtones are poliſhed; and,

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as I have ſeen them, made into ſlabs, &c. Marble (I mean the white kinds) has been thought to be a reſult of ſuch vaſt beds of ſhells, as we have formerly mentioned: theſe being, when in union with ſome liquor, broken into very minute parts, having ſettled, aſſume the hardneſs and appearance of ſtone; the veins in which are ſuch adventitious interpoſitions of earth, as accompanied the hardening maſs. The idea is probable, ſince both marble and ſhells burn into much the ſame kind of lime. Thus we ſee, that though denſer matters are ſometimes found upon lighter; yet it may be accounted for, without abandoning the idea, of the generally increaſing gravity of the terrene layers, according to their depth.

But how denſe, and compact, and ſolid ſoever be the interior beds which compoſe our globe, they are ſubject to many viciſſitudes, and to much violence; not only where ſubterraneous fires ſtruggle, till they open in ſome dreadful volcano, controuled, in part at leaſt, by the reſiſtance of ſuch well combined ſtrata; but when the tremulous earth heaves its diſtreſſed boſom, oppreſſed by a power to which reſiſtance is vain; which, perhaps, is augmented by the firmneſs of the ſtrata around its ſeat, and which, in a lighter medium, were ſooner diſſipated. I conſider pent-up fires as the cauſes of EARTHQUAKES; that, when by any means theſe are viſited by other elements (water or air), they expand them beyond oppoſition, and force a vent. If fire be a fluid appertaining to the globe, no wonder earthquakes are moſt frequent where the ſun's influence is moſt powerful; and if the electric fluid

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be a modification of that original fluid, all obſervations (which are numerous) of electric phænomena and effects, are agreeable to the principle.

Woodward aſcribed earthquakes to a ſtoppage of waters below the earth's ſurface. Theſe being accumulated, and acted on by fires (which he ſuppoſes ſtill deeper), both contribute to heave up the incumbent earth. This, he thinks, accounts for the lakes of water produced in earthquakes, as well as for the fires that ſometimes burſt from the earth's ſurface upon thoſe dreadful occaſions. Others have ſuppoſed the earth itſelf the cauſe of its own convulſions: the roots or baſis of ſome large tract being worn away, by a fluid underneath, the earth ſinking therein occaſions a tremor of the adjacent parts, ſometimes producing a ſtrange rumbling noiſe, and ſometimes inundations of water.

Without determining, a ſubject which has employed, on various ſchemes, the ſentiments of thoſe beſt ſtudied in natural cauſes, I ſhall relate ſomewhat of their effects, as communicated by eye witneſſes.

The greateſt we find in antiquity, is that mentioned by Pliny, in which twelve cities in Aſia Minor were ſwallowed up in one night, of which we have a monument remaining.

That A. D. 1693, whoſe damages were chiefly in Sicily, was felt in Germany, France, and England; extending a circumference of two thouſand ſix hundred leagues; chiefly affecting the ſea coaſts and great rivers, and being more perceivable upon mountains than in valleys.

The earthquake in Jamaica, A. D. 1692, was very terrible; in two minutes time it deſtroyed the town of Port Royal, and ſunk the houſes in a gulph forty fathoms deep. It was attended with an hollow rumbling noiſe, like thunder; in a minute, moſt of the houſes, and their inhabitants, were ſunk under water. While they were thus ſwallowed up on one ſide of the ſtreet, on the other, the houſes were thrown into heaps; the ſand of the ſtreet riſing like the waves of the ſea, lifting up thoſe that ſtood upon it, and immediately overwhelming them in pits. The wells diſcharged their waters with moſt vehement agitation. The ſea felt equal turbulence, burſting over its mounds, like a deluge. The fiſſures of the earth were in ſome places ſo great, that one of the ſtreets appeared twice as broad as formerly. In many places it opened and cloſed again, and continued this agitation ſome time. Two or three hundred of theſe openings might be ſeen at a time: in ſome, people were ſwallowed up; in others, the earth cloſing caught them by the middle, and cruſhed them inſtantly to death. Other openings ſwallowed up whole ſtreets; others ſpouted up cataracts of water, drowning ſuch as the earthquake had ſpared. The whole was attended with the moſt noiſome ſtench; while the thundering of diſtant falling mountains, the ſky overcaſt with gloom, and the craſh of falling habitations, gave unſpeakable horror to the ſcene. This dreadful calamity deſolated the whole iſland; ſcarce a planter's houſe was left: in many places appeared great pools of water, which, when dried, left only plains of barren ſand, without veſtige of former inhabitants.

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Moſt of the rivers were ſtopped up by the falling in of the mountains; and it was ſome time ere they made themſelves new channels. The mountains ſeemed particularly attacked by the ſhock; and it was ſuppoſed that the principal ſeat of the concuſſion was among them. Thoſe perſons who were ſaved, got on board ſhips in the harbour, where many remained above two months; the ſhocks continuing during that interval with more or leſs violence every day.

It is impoſſible to forget the effects of ſuch calamity at Liſbon, where that metropolis ſuffered not only by the earthquake, but by its follower, fire; and where the quay, while loaded with people, ſunk at once to the bottom of the ſea. And we yet ſympathize for the deſolations which ſo lately viſited Calabria, and enveloped in ruin that once delightful country; of which we have accounts by the very obſervant Sir W. Hamilton. But one of the moſt ſtriking, becauſe moſt minute, accounts of ſuch an event, we have in Kircher; who tells us, that he left Meſſina, March 24, 1638, arrived the ſame day at the promontory of Pelorus, intending for the city of Euphæmia, in Calabria. "Providence ſeemed to croſs our deſign, being obliged by bad weather to continue three days at Pelorus. Wearied with delay, we reſolved to proſecute our voyage. Proceeding onward, and turning my eyes to Ætna, I ſaw it eject large volumes of ſmoke, which entirely covered the iſland, and blotted out the ſhores. This, with a dreadful noiſe, and a ſulphureous ſtench, filled me with apprehenſions of impending calamity. The ſea itſelf wore a very unuſual appearance; like a lake in a violent

ſhower of rain. My ſurpriſe was increaſed by the calmneſs and ſerenity of the weather; not a breeze, not a cloud which might be ſuppoſed thus to terrify all nature. I warned my companions of an approaching earthquake; and making for ſhore, with all diligence, we landed at Tropæa, happy and thankful for having eſcaped the dangers of the ſea.

"We had ſcarce arrived at the Jeſuits College, in that city, when our ears were ſtunned with an horrid ſound, reſembling that of an infinite number of chariots fiercely driven, the wheels rattling, and the thongs cracking. A moſt dreadful earthquake enſued; ſo that the tract whereon we ſtood vibrated, as if we were in the ſcale of a wavering balance. This motion ſoon grew more violent; and being unable to keep my legs, I was thrown proſtrate on the ground. In the mean time, the univerſal ruin round me redoubled my amazement. The craſh of falling houſes, the tottering of towers, the groans of the dying, all contributed to raiſe my terror and deſpair. On every ſide I ſaw nothing but ruin, and danger threatening wherever I ſhould fly. I commended myſelf to God as my laſt great refuge. At that hour, O how vain was every ſublunary happineſs! wealth, honour, empire, wiſdom, uſeleſs ſounds! empty as bubbles of the deep! After ſome time, however, finding myſelf unhurt amid the general concuſſion, I reſolved to venture for ſafety, and running as faſt as I could, reached the ſhore, almoſt terrified out of my reaſon. Here I found the boat from which I had landed, and my companions, whoſe terrors were even greater than mine. Our meeting was

not of that kind where every one is desirous of telling his own happy escape; it was all silence, and a gloomy dread of impending terrors.

"Leaving this seat of desolation, we proceeded along the coast, and came, next day, to Rochetta, where we landed; the earth continuing violently agitated. We were scarce arrived at our inn, when we were once more obliged to return to the boat; and in about half an hour, we saw the greatest part of the town, and the inn at which we had set up, dashed to the ground, and burying all its inhabitants beneath its ruins.

"Thus proceeding, in our journey, finding no safety at land, yet, from the smallness of our boat, having very dangerous continuance at sea, we at length landed at Lopizium, a castle midway between Tropæa and Euphemia, to which city we were bound. Here appeared nothing but ruin and horror; Strombalo, sixty miles distant, belching forth flames, with a noise which I could distinctly hear. But my attention was quickly turned from remote to contiguous danger. The rumbling sound of an approaching earthquake, which we by this time were grown acquainted with, alarmed us; every moment it grew louder, and approached nearer; the place whereon we stood now began to shake most dreadfully; so that unable to stand, my companions and I caught hold of whatever shrub grew next us for support.

"This violent paroxysm ceasing, we proposed proceeding to Euphemia, that lay within sight. While preparing, I turned my eyes toward the city, but saw only a frightful dark cloud, resting on the place. This the more surprised us, as the

weather

weather was very ſerene. We waited, therefore, till the cloud was paſt away: then turning to look for the city, it was totally ſunk. Wonderful to tell! nothing but a diſmal and putrid lake was ſeen where it had ſtood. We looked for ſome one that could relate its cataſtrophe, but ſaw none. All was become a melancholy ſolitude, a ſcene of hideous deſolation. Thus proceeding penſively along, in queſt of any human being that might give us ſome little information, we at length ſaw a boy ſitting by the ſhore, ſtupified with terror. Of him, we inquired concerning the fate of the city; but he gave us no anſwer. We entreated him with every expreſſion of tenderneſs and pity; but his ſenſes were quite wrapt up in contemplation of the danger he had eſcaped. We offered him victuals, but he ſeemed to loath the ſight. We perſiſted in our offices of kindneſs; but he only pointed to the place of the city, like one out of his ſenſes; and then running up into the woods, was never heard of after. Such was the fate of the city of Euphemia."

After theſe relations, in which are many particulars to be obſerved, whatever I might remark muſt needs enfeeble their effect: I am willing that the ſympathy, which I perceive in the countenances of my auditory, ſhould have its full power, and their compaſſion its free exerciſe; unſuppreſſed be benevolent commiſeration; we ſhall more ſenſibly feel the felicity of our country in general exemption from ſimilar devaſtation; we ſhall more readily conſign the globe we inhabit to its ultimate diſſolution, of which theſe ſeem ſo many foretokens; and we ſhall more aſſiduouſly cultivate thoſe ſublime principles, whoſe value,

importance,

importance, and dignity, ſhall beſt appear when all around is enwrapt in deſolation: taught by which, we ſhall regard this tumultuated world as our reſidence, not our manſion; and ſhall ſee, that theſe occaſional inſtances of terror are little impediments to our general welfare, have little effect on our principal intereſts, and hinder not (perhaps rather augment) the propriety of placing us as rational creatures in ſo tranſitory a ſtation, where they *ſeem* to ~~contract~~ countenance the uſual benignity of creative power toward thoſe inhabitants of the globe, who are next to become the ſubjects of our diſcourſe.

LECTURE

LECTURE III.

WE concluded our laſt diſcourſe, LADIES and GENTLEMEN, with mentioning ſeveral terrific phænomena, whoſe ravages ſeem to forbid the ſettlement and increaſe of inhabitants, on a globe occupied by ſuch deſtructive reſidents; they ſeem to counteract the very exiſtence of animated beings, and to render hopeleſs every effort for their ſettlement or ſupport. Notwithſtanding which ſtate of things, I am now to remind you, that we actually find this globe, our habitation, replete with variety of creatures, of different and diſſimilar powers, inclinations, and manners; all of them liable to events apparently contrary to their well-being, yet all of them maintaining, and perpetuating that ſtation in the ſcale of exiſtents, which appears to have been their original appointment.

There are many, and much worſe cauſes of deſtruction attached to every race and ſpecies of creatures, than what we have related as connected with, or ariſing from, the globe; every rank has enemies in ranks above or below it; every individual has other individuals who are ſtrongly prompted to moleſt, or deſtroy it: nor are theſe foes deſtitute of power, or ſagacity, ~~or inclination~~. How then ſhall they fail of thei purpoſe? Or if ſome are diſappointed, if they miſs their opportunity,

portunity, or relinquiſh the chace, what ſecurity has the devoted victim of eſcaping from others? or what proſpect has he of prolonging that exiſtence which now he enjoys?

Ever provident of what *might be*, while unremittingly attentive to what *is*, the Great Author of Nature has mingled with every faculty of every creature a certain ſomewhat, which enables, as well as diſpoſes it, to provide for its own welfare; and though the degrees of exiſtence (may we ſo term it?) which come under our notice are extremely different, though ſome creatures ~~ſeem~~ are endowed with numerous privileges, while others ſeem *put off* with bare ſenſation; yet even the laſt, the leaſt, the loweſt, has powers ſufficient for protection, and defence againſt ſurrounding dangers.

If we were to compoſe a SCALE OF LIFE, we ſhould naturally place loweſt on ſuch a ſcale that living being which poſſeſſed *feweſt* of thoſe ſenſations, or means of ſenſation, which ſeem appropriate to animated matter. We ſhould alſo endeavour to aſcertain as the loweſt on ſuch a ſcale, that being which poſſeſſed in the *feebleſt degree* that ſmall ſhare of ſenſation which belonged to it. From this we ſhould riſe gradually to thoſe who poſſeſſed ſtrong degrees in one particular branch or diviſion of ſenſation; or thoſe who poſſeſſed ſeveral ſenſations, though in moderate degrees. We ſhould find that the greateſt ſhare of ſagacity would ſeem attached to thoſe beings, which, together with various means of ſenſation, poſſeſſed the greateſt proportion of *impreſſion* or *intenſity* in each, ſeparately conſidered.

The means of ſenſation, or thoſe channels which communicate impreſſions to us, we term SENSES. I take for granted, that Ideas are received by theſe. Though ALL theſe qualities are neceſſary to the perfection of life, yet life *may* be ſupported while attended by only ſome of them.

When I aſſert that Ideas are received by the Senſes, I admit that certain ideas are in their nature *diſtinct* from thoſe which it is the office of any ſenſe to introduce: for a certain conſciouſneſs of perſonal *exiſtence*, or *identity*, ſeems independent of the exertion of any ſenſe. Creatures deprived of hearing are not leſs conſcious of their exiſtence; creatures void of ſight are yet aware of their individuality; and, though utterly unable to ſurvey their own dimenſions, are extremely well acquainted what thoſe dimenſions are. There ſeems alſo, as independent of the miniſtration of the ſenſes, an idea of ſelf-protection and defence: for, without examination of minute circumſtances, or ſcrutinizing inſpection of its aſſailant, every creature when aſſaulted has inſtant recourſe to that mode of protecting itſelf, in which it is conſcious its greateſt ſtrength is placed.

I know not how far I may be juſtified in placing among ideas diſtinct from thoſe tranſmitted by the ſenſes, the talent of exerting to the beſt advantage that means of procuring food, which is attached to every creature. If hunger itſelf may not be thought independent of the ſenſes, yet it muſt be owned, that it ſhews itſelf much too early for us to perceive its pro-

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greſs or its relation: for the lamb juſt dropped applies inſtantly to its mother's teat. What example has it obſerved, that it may imitate? And the young polypus, juſt ſeparated from its parent ſtock, expands its arms that it may catch its prey. Who taught it, that ſuch was the mode in which it was to ſeek its maintenance? Who taught it, that its native element abounded with inſects? that theſe were adapted for its food? that the intent of its arms was to entrap theſe? Neither ſight, nor hearing, nor any other ſenſe, had brought information that ſuch was the manner of polypi.

The fact ſeems to be, that the ſenſes, though of great importance and concern to life, yet being ſometimes, occaſionally, or at intervals, ſuſpended, or capable of being ſuſpended, they may not be *implicitly* relied on, where ſo great a concern as life is at ſtake. A certain promptitude or diſpoſition is therefore ſuperadded, whoſe intuitive vigilance neither ſlumbers nor ſleeps. This diſpoſition, I believe I may without offence call INSTINCT; and this we find exerted, as I ſaid, whenever life is at ſtake, whether that life be attached to the individual exerting this inſtinct, or be expected to deſcend from it.

The ſcale of being is diſtributed into ſo minute gradations, that it is always perplexing to diſcover where the object which we ſhould call ſuperior quits its ſuperiority, and that we ſhould term inferior exhibits inferiority. If in two diſtinct ſpecimens with which we are acquainted, we imagine we diſcover this diviſion, two other ſpecimens of the ſame kinds, the ſame

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natures, the ſame properties, ſhall often contradict the teſtimony of the former, and enthrall in confuſion the reaſonings we have adopted reſpecting them. Thus we find the boundaries of the animal and vegetable kingdoms exceeding ill defined: ſome animals ſeem more allied to the vegetable tribe than other vegetables appear to be; and (converſely) ſome vegetables ſeem almoſt fit to be claſſed among animals, in preference to certain animals on which we beſtow that title. Nor is it eaſy, eſpecially on ſome hypotheſes, to diſtinguiſh a vegetable from a ſtone: for if we mention its growth, ſtones ſay they grow; if we ſay ſtones are brittle in their natures, ſo are certain plants, hence called *ſtony plants (lithophytes)*. And while corals were thought to be plants (which doubtleſs they reſemble), they were the conſtant ſubject of appeal, as uniting the vegetative increaſe which denotes the ſtructure of a plant, to the hardneſs and poliſh of ſtones themſelves.

If there be any ſuch thing as primitive earth remaining, I conceive we may refer to thoſe Alps of granite, whoſe texture ſeems beſt fitted for reſiſtance and duration, as the moſt probable ſpecimens of it. Theſe do not grow. If there be any change in them, they rather decay, though that decay is not that I know of any where aſcertainable. But, if there be any depoſition of lapidific matter, which in a great length of time is, by repeated acceſſions, become a quarry, unleſs it appears that the ſource of thoſe acceſſions is exhauſted, I ſee no impoſſibility attending the idea of its growth. In conſequence, it

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may happen, that where former ages had excavated ſuch quarries, preſent times may find them reſtored; and till they are replete, ſuch effect ſeems reaſonable to expect. But, after all, this ſeems very different from our ideas of vegetation; for though ſome vegetables require long periods of time to attain perfection, yet we know none which in any degree reſemble the ſlow increaſe of quarries; none which withhold every appearance of life at all ſeaſons, or remain totally unaffected by the changes which occur in that fluid wherein they are ſtationed. Let inſenſibility, therefore, be the diſtinction of ſtones, and of all that appertains to the mineral kingdom; which, if advancing in degrees of life, is by its tardineſs beyond the poſſibility of obſervation; if proceeding in any manner toward any point of maturity or perfection, ſeems likely to be conſumed with the globe itſelf, ere it attain that happy diſtinction.

Diſmiſſing our remarks on the mineral kingdom, we proceed to notice that kind of life which the vegetable kingdom exhibits. It is, indeed, exceeding difficult to define in what LIFE of any kind conſiſts. Being ourſelves capable of motion, we connect the idea of motion with that of life, and are hardly perſuaded that a perpetual attachment to one ſpot, a ſeeming inſenſibility to injuries, a total ſilence of complaint, can unite with life. I believe we may ſafely aſſert, that where there is growth there is life; that whatever ſubject increaſes, or advances

vances toward maturity, its progreſs is the conſequence of a vital principle; which principle exerts itſelf to aſſimilate other particles to thoſe which it already enlivens. This power is notorious in plants, which ſeem poſſeſſed of little or no apparent properties of life beſides. Let us for a moment conſider what is implied in this propoſition, 1. A mechaniſm of ſtructure fitted to receive food. 2. To digeſt it. 3. A pliancy of parts permitting addition to parts already formed. Excluding every idea of parts, and conſtructions of parts, neceſſary to fertility, theſe ſeem to be the loweſt functions of life, which admit no diminution, and which we either find, or muſt allow, wherever increaſe or growth exiſts. But we may add to this firſt principle as great variety of principles as we pleaſe; and having eſtabliſhed this foundation, the ſuperſtructure of which it is capable is unlimited.

I deſign not in this Diſcourſe to regard vegetables further than they furniſh inſtances of various degrees in life. I think I have begun with the loweſt degree. In advancing, we find, that though vegetables ſeem to us to have little *ſenſation*, it is rather becauſe we ſeek for *expreſſions* of their ſenſations in a manner ſomewhat analogous to thoſe we have been accuſtomed to elſewhere, than becauſe they are totally and univerſally deſtitute of ſenſation.

Though the various modes of expreſſing ſenſations employed by ſubjects of various natures be very different, yet they are not leſs real; only be it remembered, that they muſt be

conformable to the neceſſities, or natural wants, of the ſubject. Where natural wants are few, there can be little variety of expreſſion; and the expreſſion adopted will be proportionably ſimple and uniform. Light is neceſſary to a plant; to its comfort and enjoyment, if not to its exiſtence. If a plant be kept in a dark room, it may maintain a languid life: if light be admitted at one part of the room, it will bend toward that part, will deprive its oppoſite branches of nutriment, (or at leaſt ſeemingly neglect them) and thoſe only which are viſited by the light, however feeble be its rays, will appear to thrive: but if the full vigour of the ſun be admitted, the plant feels the ſtimulus, and is proportionately affected. It is certain plants which love water will bend *to* the water, (Who ever ſaw a weeping willow bend *from* the brook on whoſe banks it was planted?) or will ſhoot out branches, or roots, towards water: and we have an inſtance of a tree, growing in a church-wall with very little earth, bending *down* ſome of its branches till they reached the ground, while the other branches roſe upwards. To what can this be attributed, but to a deſire of connection with its natural ally and ſupport?

There is certainly an advance in the ſcale of life, from plants which ſeem poſſeſſed but of mere exiſtence, (which yet doubtleſs increaſe by acceſſion of parts, and propagate their kind) to thoſe which ſeem ſenſible of effects paſſing around them: the feelings of the former, if they feel, are obtuſe and blunt;

thoſe of the latter are more delicate and ſuſceptible. Plants which by a kind of foreſight ſhut up their leaves before rain; thoſe which only unfold themſelves to the ſun, and cloſe when he withdraws; thoſe, on the contrary, which open only in an evening, (and principally to the moon); theſe, I ſay, muſt be of finer contexture than thoſe void of feeling: they have alſo in general greater variety of parts and contrivance united in their ſtructure, and uſually exhibit greater variety of appearance, not to mention elegance of form. As to the ſeemingly greater advance toward exalted life which has been noticed in the ſenſitive plant, and others, which ſhut their leaves at the approach of the hand, or other body, I am not certain that this ariſes from any additional degree of ſuſceptibility in the plant itſelf; it is probably nothing beyond an effect of certain electric principles. And as to plants, ſome part or other of which is always in motion, theſe, though very pretty to look at, (I have inſpected them with much pleaſure) and though termed animal-plants, *(Zoophytes)* yet perhaps may be referred to the ſame principles; as I never heard that this exertion (or rather ſimple motion) of their branches effected any purpoſe, that they caught any prey, or in any other manner contributed to the ſupport of the plant.

From theſe ſlight hints it is clear, that among the vegetable tribes are diſperſed various degrees of life; ſome ſeem to exhibit very powerful ſigns of ſenſation, and eſpecially in their flowery parts, *i. e.* thoſe peculiarly formed for preſervation of

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their ſpecies, ſeem ſenſible of a very ſlight ſtimulus. After all, that is but an inferior kind of life which is always united to one ſpot, which poſſeſſes no loco-motive powers, but like the ground whereon it grows, abides every event, proſperous or adverſe, a calm or a ſtorm, with the ſame cautionleſs expoſure; which unable to avoid accidents, to retreat from calamity, finds its ſecurity in *inſenſibility*, and to whom more exquiſite feelings were only additional infelicity. It is true, that many trees are well protected by ample folds of bark; but that which is formed only for endurance, is certainly remote from happineſs, and among the lower ranks of exiſtence. We muſt therefore turn to the claſſes of animals in ſearch of life more truly alive.

We muſt not, however, in paſſing from Vegetable Life to Animal, expect any violent tranſition, or ſudden interval. If we ſay a vegetable is confined to one ſpot, wherein differ many kinds of ſhell-fiſh which are equally conſtant to their native rock? If we advert to internal conſtruction, the peculiarities neceſſary to life are not ſtronger or more diſtinct in one than in the other. Nor do any faculties (ſuch as in more perfect creatures we call Senſes) appear: What ſuppoſable ſight has an oyſter? What hearing? What conception beyond that of ſelf-ſecurity, or ſelf-maintenance?

Indeed I think we may conſider moſt inhabitants of the waters as inſtances of inferior degrees of animal faculties; debarred by their very nature from acquiring any reſpectable ſhare of knowledge, and directed by inſtinct, not ſentiment,

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by impulſe, not feeling. Terreſtrial animals, deſtined to reſidence in a finer fluid, to pleaſures more varied in preparation and in nature, exhibit greater variety of faculties capable of enjoyment; related to the earth, whoſe ſuperficies they perambulate, whoſe diverſities they ſurvey, whoſe multiplied productions they freely examine, and ſelect; related likewiſe to the air, which all of them breathe, and in which ſome of them fly, they are furniſhed with organs reſpectively adapted to theſe different elements.

Multiplied organs, if they no not imply multiplied ſenſations, yet evidently furniſh ſuch opportunity for them, as leads us to expect will be embraced; and this we find the fact, in regard to ſome ſenſe or other. I ſay to ſome ſenſe or other: for frugal nature well knowing the value of every ſenſe, ſeldom imparts pre-eminent degrees of ſeveral to one ſubject; if ſhe beſtows keenneſs of ſight to one, hearing and ſmelling are deficient; if ſmelling is acute, other faculties are dull. Birds, whoſe ſight is perhaps ſuperior to that of all creatures, have little taſte; the lion, whoſe hearing is wonderfully accurate, has no ſmell. We even ſee in different kinds of dogs, ſome hunt by ſight, others by ſagacious tracing the ſcent of their game. And thus a balance is maintained throughout all ſpecies; what is given to one in one inſtance, compenſates for the ſuperiority of others in other inſtances; as what is *drawn back* from ſome, is by way of *equalization* to others; by which diſpoſition ſomewhat like a *par* is maintained among creatures.

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If we trace any one ſenſe, from the loweſt degree of it in animated nature, to the higheſt which has come to our knowledge, we find a regular, imperceptible progreſſion, aſcending by ſteps of ſo little riſe, as are barely ſufficient to manifeſt that one is not the other: though to determine wherein conſiſts a difference is not eaſy. What enjoyment of ſight has the earthworm? What ſmall enjoyment the mole? How limited thoſe creatures whoſe eyes look only one way, immoveable to other quarters! Some eyes are fixed; the head muſt be turned to permit the view of objects; ſome heads are fixed, the eyes roll round in their ſockets without impediment, nay can inſpect objects placed before and behind at the ſame time; ſome eyes enjoy light as ſplendor itſelf; others, too ſenſible of light, are diſturbed by too much, and only exert their faculties by twilight; two eyes are enough for ſome animals; others have ſix or eight; others ſo many hundreds; others ſo many thouſands; ſome eyes ſhew objects tolerably truly in their dimenſions; others magnify and enlarge them; to ſuch an inſect is a giant! Nor is leſs various the ſituations choſen for the ſeat of this ſenſe: the eyes of ſome creatures are placed deep in the head, and protected by the frontal bones; others are brought forward, and almoſt ſtand out of the head; others again are poſitively *detached*, and to look for the eyes of the animal, we muſt examine a diſtance of half his length from the head. Such are the teleſcopic tubes of the ſnail.

If we advert to other ſenſes, we find no leſs diverſity of nature. One ſhould think feeling were a ſenſation ſo decidedly

neceſſary and indiſpenſible, that no animal could exiſt without ample ſhare of feeling: what then ſhall we ſay to ſubjects, of which a part may be broken off (as a leg or a tail) with ſo little detriment to the animal, that he never complains? nay, if the fracture be made at an inconvenient part, breaks off (himſelf) what remains, to a proper part for the renewal of the member? What ſhall we ſay to creatures, which in a fright caſt their claws (as lobſters)? they are not broken off by accident, or force, but the creature actually ſeparates a part of itſelf: Is this conſiſtent with any exalted degree of feeling? What ſhall we ſay to animals, whoſe ſleep is ſo profound, that ſcarce any injury can awake them? While on the contrary, others are "tremblingly alive all o'er;" touch the thread of a ſpider's web, the ſlighteſt notice affects the ſpider.

The proportions of hearing are equally diſſimilar; ſome are almoſt deaf; others exquiſitely minute. In proof of the latter, witneſs the whole claſs of ſong-birds: What accuracy of tone! what variety of modulation! The differences in power of ſmelling nature communicates, we have hinted; and when we reflect, that ſome animals have ſagacious palates, and chooſe but few plants for food, out of many that are offered; while others devour by preference carrion that taints the breeze; and others again ſwallow indiſcriminately whatever they find before them; we muſt allow equally unlimited degrees of taſte.

In obſerving thoſe diſpoſitions which we have noted as diſtinct from ſuch as are furniſhed by the ſenſes, we have

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opportunities of admiring the infinitely varied reſources of nature. How different the methods of ſelf-ſupport and ſelf-protection! Such a creature riſes high above the powers of its adverſary; ſuch another conceals itſelf, by a thouſand ingenious artifices, from the notice of its enemy; this is furniſhed with dreadful teeth, or enormous claws, and, confident in native ſtrength and weapons, knows no fear; capable not only of defence, but of conqueſt, it defies danger; that finds ſecurity in its timidity, and, on the leaſt alarm, outflies the wind. One ravages boldly, another by ſtealth. The elephant depends on its bulk, the monkey on its agility, the fox on its arts, the hedge-hog on its ſpines. Who ſhall purſue the ſnake in its winding path, through crevices of every form and dimenſion? Who ſhall diſtinguiſh the camelion in its varying colours, correſpondent to the earth or the tree on which it crawls? What need has the ſnail of a den? he carries his houſe on his back; or what the armadillo, or the tortoiſe, whoſe external covering is armour itſelf.

What variety of methods in catching prey are diſtributed among creatures! The lion roars in the foreſt; the beaſts tremble and fly; the noiſe of their flight directs his purſuit. The eagle riſes high into air, yet there ſurveys a vaſt ſpace of country, with ſcrutinizing attention, and woe to the ſtraggling leveret, which thinks himſelf ſecure. The lurking tyger in the thicket, the crouching ſerpent on the tree, the dextrous ſpider, who ſpreads his inſidious web, the otter who ſwims *againſt* the ſtream, the crocodile watching in the river, the

ſhark in the ocean, are deſtructive inſtances of diverſity in this natural quality.

It ſtill remains a query, how, among ſo many dangers, the weaker races of creatures are continued? The ravenous ſhark, though his tribe be numerous, and his ſtrength abundant, yet deſtroys not the ſmaller fry; the rapacious eagle, though of diſproportionate magnitude and celerity, yet extirpates not the ſpecies of hares; nor after all the labours of millions of ſpiders, whoſe webs have covered our walls, have reached from branch to branch, or from tree to tree, has one race of flies periſhed. The anſwer to this, I would divide into the following propoſitions:—1. According to the weakneſs of creatures, their expoſure to enemies, and incapacity of defence, ſo is their FERTILITY; and (converſely) according to the ſtrength of creatures, their rapacity, and the ſlaughter they commit, as neceſſary to their ſuſtenance, ſo is their STERILITY. 2. The variety, and almoſt infinitely greater number of ſpecies, of the lower tribes of animals, very much diminiſh the expoſure and riſk of any particular tribe. If all birds of prey fed only upon hares, the chance were certainly very much againſt them; but while their moſt formidable enemies feed on many (ſay twenty) other kinds of animals of equal rank, we may reckon that only the twentieth turn falls to the lot of a hare. 3. Many of the more deſtructive ſpecies of creatures are as well pleaſed with a carcaſe as with a living animal; conſequently they do not conſume, in this inſtance, any part of ſuch ſpecies, the individual itſelf being extinct, and all the fertility and increaſe

of which it was capable, having been employed towards maintaining the community of its ſpecies. 4. I add alſo, that the effect of climate is uſually in favour of the leſſer tribes; the equatorial countries are notorious for the encreaſe of inſects (which are abundant to a very noxious degree) and ſmaller animals; but birds of prey are not proportionally multiplied, though they are greatly enlarged in powers and dimenſions. 5. The immenſe progeny of fiſh, and their various kinds, exceeds the rapacity of the deſtroyers of their own ſpecies to conſume; and adds to the chances of eſcape of the leſſer animals, as it diverts from them (entirely) a great proportion of birds of prey, and occaſionally ſupplies the hunger of the moſt deſtructive; which, in winter-time eſpecially, often haunt the ſhores.

I beg leave to add a few remarks, in ſupport of ſome of theſe principles; *a propos*, of fiſh: they live totally (ſo far as we know) upon each other, the ſtronger devouring the weaker. How many eggs, then, ſhould a ſmall fiſh be parent of, in order to enable its ſpecies to maintain its rank among the inhabitants of the water? Ten thouſand? Ten thouſand would not ſuffice; for conſider the chances againſt it. Female fiſh eject their ſpawn for the male fiſh to viſit and impregnate: All may not be viſited by the male, much of it muſt be food for other fiſh, &c. before it attains life (and this claſs of devourers is very numerous), when the young fry appear, they are the prey of other ranks of enemies, according to their ſize, before they are capable of contributing to the conſervation of their ſpecies. Add theſe dangers together, they more than

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counterbalance the increaſe poſſible to iſſue from ten thouſand eggs; and therefore liberal nature imparts ten times ten thouſand, and ſometimes little leſs than ten times ten hundred thouſand. Obſerve, this prodigious fertility of fiſh is in the ocean, where enemies are moſt numerous and mighty. River fiſh, I believe, are ſeldom ſo prolific, as they feed partly on herbage, partly on inſects, and not excluſively on other fiſh, there ſeems leſs occaſion for ſuch extraordinary powers.

In proof of this ſtatement, I ſhall not ſo much appeal to the teſtimony of thoſe who have counted the eggs in the roes of cod-fiſh, &c. by the microſcope, as remind you of thoſe immenſe ſhoals of ſprats, herrings, and mackarel, which every year viſit our coaſt. Amid ſo many difficulties and dangers, not omitting numbers of whales which follow the ſhoals, and the induſtrious exertions of man himſelf, (which ſweep thouſands and millions into his nets), amid ſo many dangers, in a voyage from the north pole, and the mountains of ice, round the Britiſh iſlands, and into the Atlantic, could this prodigious emigration regularly be maintained, unleſs each individual poſſeſſed in itſelf very ſurprizing powers of renovation in a future progeny? If thoſe fiſh which viſit us, are only detachments from the main body, how vaſt is that body to bear ſuch a loſs, ſince, probably, few return to it. If they are the body itſelf, what muſt we think of thoſe few which return, ſince the next year they appear without the ſmalleſt diminution of their numbers?

Much

Much after the ſame proportion, though very inferior in point of numerous iſſue, are many inhabitants of the land. If any of my auditory have amuſed themſelves with keeping ſilk-worms (which I remember I did, when young) they muſt have noticed the prodigious number of eggs depoſited by a ſingle worm; as if any have had the opportunity of inſpecting a bee-hive, what ſwarms are the iſſue of a few, and indeed are underſtood to be the iſſue of one! (the Queen Bee) forty thouſand, I think, in a ſeaſon. Let me remind you, that ſmall animals (quadrupeds) which are incapable of producing ſo many at a time, breed very frequently, and while they are even young themſelves; a rabbit is almoſt always breeding, and a very numerous family of cats may be reared in a year, by whoever will *undergo* the pleaſure; theſe inſtances admitted in lieu of many, let us ſee how huge and deſtructive creatures increaſe.

An eagle breeds once a-year, and, if ſhe lays three eggs, or hatch three young ones, ſeldom rears but two; a lioneſs, one; a tigreſs, one, or two; panthers and leopards the ſame; wolves, indeed, produce more, ſo do badgers, foxes, and ſome others; but theſe are among the weaker beaſts of prey, and themſelves the prey of the ſtronger.

As to the more numerous ſpecies of lower tribes of animals, I ſhall merely hint, that we ſee many of different kinds daily, as well birds as beaſts; while an eagle, or a lion, bears a price to be ſeen; that even a fox is in ſome counties a rarity to the huntſman, while he can find plenty of hares; and otters are,

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ſo far as I know, rather uncommon; I might have added, that rapacious creatures are uſually ſo angry in their natures, or ſo often famiſhed and deſperate, that they quarrel mutually, and being inclined for deſtruction, exerciſe that talent on each other, if not more profitably engaged elſewhere.

Upon the whole, it appears, that there is ſuch a proportionate multiplication of ſome creatures, ſuch a proportionate *unmultiplication* (pardon the phraſe) of others, that rapacity gets no advantage over mildneſs, nor ſtrength and cruelty over weakneſs and inſecurity, ſo far as relates to the ſpecies.

Let us collect the evidence as it has now been offered to us; we infer, 1ſt, that life advances from its firſt principles to higher qualities, by very ſlow, ſcarcely perceptible, yet certain, degrees; exhibiting ſenſations increaſing in quantity, (*i. e.* in number) or quality (*i. e.* intenſity). 2d, That theſe ſenſations are ſo diſtributed among their poſſeſſors, that either by means of quality (in one) or quantity (in ſeveral) there is a proportion obſerved, which leaves no room for complaint, or envy: Becauſe, 3d, theſe ſenſations, or the means of receiving them, are as gradual and imperceptible in their advances (conſequently in their donation to any individual) as life itſelf. 4th, That though ſome tribes of animals ſeem poſſeſſed of very great powers to do miſchief, yet that their ſpecies has not prevailed, nor can prevail, to the extinction of the feebleſt ſpecies imaginable, being counteracted, by fertility, by diverſity, and by inſtinctive attention.

Thus, I think, we have proved the propoſition which began

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our diſcourſe, viz. that though the globe be liable to terrific phenomena, yet it is no unworthy ſeat of life; and though much worſe cauſes of deſtruction than are connected with the globe, are attached to its inhabitants, yet they have hitherto maintained, and ever will maintain, thoſe ſtations in the ſcale of exiſtents, which appear to have been their original appointment.

We have aſſerted a proportion of gifts, a proportion of fertility, let us now ſee whether we cannot trace a proportion of feelings, ſo that we may form an opinion on proportionate happineſs; for I think it a natural queſtion, why are theſe inroads, theſe depredations committed? Might no other way of appeaſing the hunger of one have been inſtituted, than a conſumption of the other?

What might have been inſtituted we cannot ſay; but we find univerſally the life of one is derived from the death of another, among all beings which are incapable of ſupport by the ſimple elements alone. When a tree converts into part of its ſubſtance, the earth, the water, the air around it, life ſeems to be promoted, without any death following; but no ſooner does this tree attempt to reproduce its kind, than it furniſhes a multitude of ſeeds with that intent;—but wherefore a *multitude* of ſeeds? Becauſe Nature foreſees, that few of theſe will accompliſh that particular purpoſe which has given them exiſtence.

Poſſibly ſome kinds of trees may make greater proviſion for increaſing their ſpecies, than what we have ſtated of fiſh; but

of theſe thouſands, how few ſhoot up into plants! Take an oak, for inſtance, whoſe ſeed is the acorn, of which many buſhels are yielded by a ſingle tree in one ſeaſon (but how many during its life!) your own recollection furniſhes a liſt of enemies waiting to conſume theſe ſeeds, in birds and beaſts; not to mention man. Suppoſe theſe acorns eaten by a bird; then has that bird prevented the life of ſo many plants, as ſhe (or he) has devoured acorns. But this bird alſo, like the tree, makes preparation for maintaining its ſpecies, and lays eggs; if we denominate eggs the ſeed of birds, now is ſhe in circumſtances ſimilar to the tree was; for a bird (a hen for inſtance) will lay two hundred eggs, yet not hatch twenty chicken; the hundred and eighty are applied to ſuſtain life in ſome other quarter. This principle we have alſo ſeen exemplified in the roe of ſome kinds of fiſh becoming the food of other kinds of fiſh. Thus it appears, that hundreds, perhaps thouſands of *poſſible* lives, are conſumed in maintaining one actual life; and thus it muſt be, on the ſimpleſt ſuppoſition that can be ſtated;—but obſerve, that it is not thouſands of ſuperior lives converted to the ſupport of an inferior; but thouſands of poſſible exiſtences, or ſcarce exiſtences, rather almoſt lives, than perfect lives, and theſe go to the ſupport of ſuperior intelligence. The bird has more of an advance toward intelligence than the tree; and moſt hens eggs, I believe, are eaten by thoſe who think themſelves far her ſuperior. Thus the matter which the tree extracted from the elements, paſſes from rank to rank

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till it reaches its ultimatum in connection with intelligence itself.

It follows, I think clearly, that whatever is moſt liable to be ſuddenly deprived of exiſtence, is the feweſt degrees removed from non-exiſtence; has, conſequently, feweſt principles of life to loſe, feweſt ſenſations are counteracted, and feweſt feelings wronged in its deſtruction. If there be degrees of life to which is connected inſenſibility, to deſtroy that life, cauſes no unhappineſs; and if the creature poſſeſſing ſuch a life has in itſelf any principle of enjoyment, which compenſates for its liableneſs to deſtruction, it may be very ſuperior on the ſcale of happineſs to its deſtroyer.

Happineſs or miſery is allied to intelligence, not to mere exiſtence; to thought, to foreſight, not ſimply to life. This granted; the abſence of thought, of foreſight, of intelligence, from creatures liable to a termination of their exiſtence from ſudden cauſes (as all cauſes to them muſt be) is their greateſt benefit, and at once equals them with every competitor; ſince all they can enjoy they poſſeſs to the laſt without allay, and all the happineſs of which they are capable attends them, while the poſſibility of its ſatisfaction exiſts, undiminiſhed by anxiety, by expectation, by any kind of dread, and at laſt the tranſition is but ſmall, from the lower degrees of comparative, or proportionate ſenſibility, to a ſtate void of every degree of every ſenſation.

But the queſtion, why are theſe devaſtations permitted? may be ſurveyed under another aſpect; and, indeed, is partly anſwered,

anſwered, by aſking, what would be the ſtate of things were they ſuſpended? If every ſeed from a tree became alſo a tree, farewel animals; the ground is occupied. If every young one of the lower ranks of animals arrived at maturity, how ſhall ſuch numerous tribes be maintained? Where ſhall we find food, or ſhelter, for ſuch hordes of animation? As things are, the inferior tribes multiply againſt their deſtroyers: in ſpite of the efforts of lions, tigers, panthers, ſerpents, and ſo forth, the antelopes of Africa multiply; ſo that every ſix or ſeven years they come down towards the Cape of Good Hope, in immenſe ſwarms, devouring the country, and always followed by lions. In the North, the lemming multiplies, and pours forth its hoſts, to the great annoyance of the inhabitants; and yet in the North are many beaſts of prey. And, to name no other inſtances, let us recollect the locuſt, that dreadful ſcourge of the fineſt parts of the globe, which conſumes at once all verdure, which in an inſtant deſolates the fields, deprives the labourer of every hope of harveſt, the keeper of the vineyard of every poſſibility of vintage, which, wherever it reaches, ſpreads famine, often plague, and death.

Monſ. Buffon relates, what I think a caſe in point; which I have, therefore, tranſlated and abridged from his Natural Hiſtory of the bird he calls the Martin. "Certain plants being ſent in earth from Madagaſcar to the Iſle Bourbon, the earth happened to contain a number of the eggs of graſshoppers, which multiplied greatly. Monſ. Des Forges-Boucher, Governor-general, and Monſ. Poivre, Intendant, ſeeing the country

country ravaged by these insects, endeavoured seriously to rid the island of them, and procured from India several pairs of martins for that purpose. The plan was in a fair way of succeeding, when the inhabitants observing these birds to scratch with eagerness in the earth newly sown, imagined they sought the grain: taking the alarm, they spread over the whole island a report of the injury expected from this bird, who was accordingly arraigned in form; his defenders insisted that he sought not the grain, but the insects inimical to the grain, wherein he proved himself a benefactor. Notwithstanding this plea he was proscribed, and two hours after the publication of his sentence, not a pair was left alive on the island. This rapid destruction was followed by rapid repentance; for the grasshoppers multiplying without impediment, soon caused regret for the loss of the martins. Eight years after this extermination, were again introduced four of these birds; they were received with transports of joy; laws were made for their preservation and multiplication; and every possible precaution taken for their welfare. In consequence, they increased prodigiously, and exterminated the grasshoppers; but no sooner were these insects destroyed, than having lost their usual and principal food, and being greatly overstocked in numbers, they had recourse for subsistence to the fruits, the dates, the figs, &c. and even attacked the corn, the rice, the maize, the beans; they also entered the dove-cotes, and destroyed the pigeons; so that after having delivered the country from one plague, they themselves became by very much a greater,

and

and more difficult to extirpate. Birds of prey ſeem the only remedy; but a remedy not to be adopted without expecting other and ſerious evils."

When we have conſidered theſe inſtances, how fooliſh, how criminal were the deſire, that all life ſhould continue to live? Rather let us acknowledge ſome obligation to birds and beaſts of prey; while ſatisfying themſelves, they benefit ſociety; while revelling in death, they furniſh ſpace for ſuperior life.

Thus, it ſeems that Nature never conſiders all animals, any more than all poſſible or embrio animals, or all ſeeds of vegetables, as uſeful; but many, perhaps moſt, for ſuperfluity; and becauſe other means are inſufficient, many ſhe deſtroys with her own hands; many periſh in the ſeverity of the ſeaſons. Who can number the millions of inſects thus devoted, not in a kingdom only, but throughout the globe? Many are annihilated in ſtorms and tempeſts (we mentioned this as one uſe of hurricanes). Thus, as carrion is devoured by vultures, leſt it ſhould pollute the circumambient air, ſo theſe leſſer exiſtences, little raiſed above non-exiſtence, are conſumed by a variety of cauſes, leſt they ſhould engroſs thoſe principles which Nature appoints to ſuperior purpoſes.

From theſe premiſes we infer, that the lower claſſes of creatures are not capable of much unhappineſs; it is beyond their powers: their capacity of happineſs is equally limited to low degrees; but theſe degrees are more eaſily, more certainly, more efficaciouſly attained, than thoſe which are more exalted.

In what they place their happineſs they ſucceed, and have no idea of infelicity, even when to us they ſeem to ſuffer.

Let me here enter my proteſt, as a man of ſenſe and ſenſibility, as a gentleman and a chriſtian, againſt every degree of wanton violence, or malevolent cruelty toward our fellow-creatures. Never may my ſentiments be wreſted to a toleration of ſuch practices; I merely ſuggeſt theſe hints in vindication, not of man's tyranny, but of nature's general principles, and (as I apprehend) general practice.

It remains to be noticed, that as ſome animals deſtroy others, ſome vegetables have the ſame diſpoſition; and though we dare hardly venture to denominate them plants of prey, yet it is certain they exhale ſuch poiſonous vapours as render all around them deſert, and blaſt all verdure within their reach; while others wind around a ~~ſturdy~~ ſtately tree, creep with inſidious convolutions over its ſtem and branches, till at length they deprive their ſupporter of that nouriſhment which ſhould ſuſtain it; thus, flouriſhing at the expence of their benefactor's life, and conſuming his very vitals; if not with the ferocity of a lion or a tiger.

By way of cloſe to this diſcourſe, I beg you to reflect, that, in order to form juſt ideas of the propriety of nature's general courſe, we muſt regard as well principles as events, on an enlarged ſcale: a partial view is no better than total overſight; ſo many combinations are of neceſſity employed, ſo many apparent intricacies are of conſequence to be arranged, that ſuperficial obſervation is incompetent to the taſk. We acknowledge, that when ſurveyed on a particular quarter, or

in particular inſtances, much that is amiſs preſents itſelf; but from this very evil reſults a more than compenſating proportion of advantage; of advantage not procurable without the intervention of ſuch evil, whoſe nature is, by its relation to evident neceſſity, transformed to good: nor is it at any time ſo great as it might be. The ſmalleſt poſſible evil is employed, no greater unhappineſs is introduced than cannot be avoided; and herein we diſcover the hand of a maſter: human talents might have ſuggeſted many ſchemes, have adopted many plans and contrivances, to little purpoſe; moſt of them would have defeated themſelves, and others would have fallen ſhort of the effect propoſed. To procure the greateſt poſſible quantity of happineſs, at the leaſt poſſible expence of evil, is a problem which can only be ſolved by INFINITE WISDOM.

LECTURE

LECTURE IV.

HAVING ſurveyed the various ranks of life; which, in infinite gradation, abound throughout nature; let us now ſee, LADIES and GENTLEMEN, what indications of ſuch ranks preſent themſelves among the component members of ſuch variety. Life which is of inferior powers is uſually moſt generally diſtributed throughout its ſubject; the branches of many kinds of trees poſſeſs ſo ſtrongly that life proper to their rank, as to be capable of maintaining it in a ſtate of ſeparation from the parent trunk, under certain circumſtances. If a branch be bent downwards to the ground, and ſufficiency of earth be heaped over it, it will ſend out ſuckers, which ſhall become roots, and will vegetate anew, on the ſpot which, by their means, affords it nouriſhment. I think the gardeners term this operation *trailing*, and take advantage of knots and promiſing ſhoots. I believe it is fact, that *roots* of moſt trees are capable of becoming *branches*, if properly expoſed to the open *air*; as branches of the ſame trees are alſo capable of becoming roots, if immerged in earth. This is remarkably notorious in the banian tree of the Eaſt Indies; whoſe branches bending around the trunk reach the ground, where taking root, they become themſelves the parents of others, increaſing, till the ſame tree, by means of its colonies,

nies, becomes ſufficiently extended to ſhelter a troop. Many *plants* are propagated by ſlips and cuttings. I infer, as I ſaid, that life in its lower degrees, is greatly *ſpread* in its ſubject, and as it ſeems to coſt nature little exertion, is freely and amply beſtowed. There ſeems to be not much, if any, pre-eminence, in regard to vitality, attached to one particular part of ſuch inſtances; but all ſeem nearly, if not entirely, on a level: and all members of ſuch body ſeem capable of performing the functions of life. Leaves have equal kind of breathing, of feeding, of perſpiration, with the trunk of a tree; and it is not eaſy, in many vegetables, to deprive a branch of life, without actual ſeparation from the ſtem, and from the earth, which is the appointed medium of ſuſtaining life. But in higher ranks of life, there is nothing of this generality, this diviſibility of vitality; an individual being complete in himſelf, having a more elaborate contrivance neceſſary to maintain each of his functions, and each appointed to its peculiar member.

A tree may receive nouriſhment by its leaves (they drinking in the water wherewith they are aſperſed); but an animal muſt receive his food, and convey it to one proper and determinate part. There is no *planting* parts of animals with intent of reproduction; the ſeparated part of neceſſity periſhes, becauſe deprived of the offices neceſſary to its maintenance, for which it depends on others. The members of plants are uſually more numerous (as branches) but greatly alike; the members of animals of the more perfect kinds are more ſelect, more diverſified, and appropriate, as the offices for which they

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are deſigned are more diſtinct; and this ſeems analogous to the nature of that nouriſhment proper to each rank. The food of plants may be conſidered as elementary; that of animals has undergone various changes, and acquired various properties in its vegetable ſtate. It is, I ſay, removed one degree, at leaſt, from its elementary nature, as when it becomes by digeſtion part of an animal, it is yet further removed from its original properties; accordingly we find, that the parts neceſſary to aſſimilate the food of animals vary, correſpondently to this intention. Thoſe which eat graſs have ſeveral ſtomachs; thoſe who devour fleſh have only one. The bowels of the latter are uſually of much leſs length than thoſe of the former; and, upon the whole, their food paſſes off very much quicker, ſo that they are ever hungry. They ſatiate themſelves, are repleted, and overcharged, when opportunity offers; but ſoon they are empty and ravenous as ever. This is notoriouſly the caſe with the wolf; whereas animals who ruminate, are long in digeſting their food, and very gradually perform that office. The reaſon is obvious: to aſſimilate vegetable ſubſtance with fleſh (to which it has little apparent reſemblance) requires a change greater by far than to aſſimilate the fleſh of one animal to that of another.

If we notice the various natures of the food furniſhed to various degrees of life, we find additional reaſons for the above diverſity: the elements are nearly alike all the world over, and though ſome variation of certain principles may be ſuppoſed, yet air continues to be air, and water is ſtill water; but how different are the properties of theſe elements, when

transformed

transformed into the juices of plants? Some are wholeſome and ſweet, ſome are deadly and bitter. The effects of plants on animal bodies are extremely different; that nouriſhing, that without nutriment; that exhilarating, that ſaddening; that permitting free exerciſe of ideas, that inducing madneſs. Animals generally chooſe (inſtinctively) thoſe which are ſalubrious; and among a variety not free from danger, are ſeldom injured by what is noxious, if what is ſafe is within their attainment. There is no occaſion for the exerciſe of choice in vegetables; they muſt take their maintenance as it comes, uniform and ſimilar, therefore generally fit for them, at leaſt ſo far as related to the climate of which they are native.

It muſt alſo be obſerved, that animals of the ſuperior kinds have greater variety in the matter which compoſe them, or at leaſt, that it appears under greater variety of form: if the ſap of trees may be thought analogous to the blood of animals, yet there ſeems nothing in a vegetable anſwering to the many liquors and humours of animals, to the many different kinds of ſolids which compoſe any animal body of the higher claſs; all ſeems, though very artful, yet comparatively ſimple, leſs complex, leſs intricate, leſs refined, as it were, void of thoſe indications which ſeem to expreſs an approach toward fitneſs for the reſidence of intelligence.

It is confeſſed, that in many reſpects there is great reſemblance in certain principles; and having, as above, juſt hinted at ſome marks of diſſimilarity, let us now attend to others of reſemblance, of which I ſhall ſelect part from an Eſſay of Dr. WATSON, now Biſhop of Llandaff.

The perception of man ſeems to be indefinitely greater, when compared with that of coralines, ſea-pens and oyſters, than the perception of theſe, which are allowed to be animals, doth, when compared with the ſigns of perception manifeſted by a variety of what are called vegetables. Spunges open and ſhut their *mamillæ*, corals and ſea-pens protrude or draw back their ſuckers, ſhell-fiſh open or keep cloſe their ſhells in ſearch of food or avoidance of injury; it is from theſe and ſimilar muſcular motions that we judge the beings to which they belong to have perception, that is, to be animals. Now in the vegetable kingdom, we may obſerve the muſcular motions of many plants to be, to the full, as definite and diſtinguiſhable as thoſe of the claſs of animals juſt mentioned. The plants called *Heliotropæ* turn daily round with the ſun; by conſtantly preſenting their ſurfaces to that luminary, they ſeem as deſirous of abſorbing a nutriment from its rays, as a bed of muſcles muſſel doth from the water, by opening their ſhells upon the afflux of the tide. The *Flores Solares* are as uniform in their opening and ſhutting as animals are in their times of feeding and digeſting; ſome in theſe motions do not obſerve the ſeaſons of the year, but expand and ſhut up their flowers at the ſame hour in all ſeaſons; others, like a variety of inſects which appear, or not, according to the heat of the weather or climate, open later in the day, or do not open at all, when they are removed from a ſouthern to a more northern latitude. Whatever can produce any effect upon an animal organ, as the impact of external bodies, heat and cold, the vapour of burning ſulphur, of volatile alkali, want of air, &c. are found to act

alſo upon the plants called ſenſitive. But not to inſiſt upon any more inſtances, the muſcular motions of the *Dionæa Muſcipula*, lately brought into Europe from America, ſeem far ſuperior in quickneſs to thoſe of a variety of animals. Now to refer the muſcular motions of ſhell-fiſh and zoophytes, to an internal principle of volition, to make them indicative of the perceptivity of the being; and to attribute the more notable ones of vegetables to certain mechanical dilatations, and contractions of parts, occaſioned by external impulſe, is to err againſt that rule of philoſophizing which aſſigns the ſame cauſes for effects of the ſame kind. The motions in both caſes are equally accommodated to the preſervation of the being to which they belong, are equally diſtinct and uniform, and ſhould be equally derived from mechaniſm, or equally admitted as criterions of perception.

Exſpiration and inſpiration, a kind of larynx and lungs, perſpiration, imbibition, arteries, veins, lacteals, an organized body, and probably a circulating fluid, appertain to vegetables as well as to animals. Life belongs alike to both kingdoms, and ſeems to depend upon the ſame principle in both: ſtop the motion of the fluids in an animal limb by a ſtrong ligature, the limb mortifies beyond the ligature, and drops off; a branch of a tree under like circumſtances, grows dry, and rots away. Health and ſickneſs are only other terms for tendencies to prolong or to abridge the period of life, and therefore muſt belong to both vegetables and animals, as being both poſſeſſed of life. An eaſt wind, in our climate, by its lack of moiſture, is prejudicial to both; both are ſubject to be froſt-

froſt-bitten, and to conſequent mortifications; both to languiſh in exceſſive heats; both experience extravaſations of juices from repletion, and pinings from inanition; but can ſuffer amputation of limbs without being deprived of life, and in a ſimilar manner both form a *callus*; both are liable to contracting diſeaſes by infection; both are ſtrengthened by air and motion: *Alpine* plants, and ſuch as are expoſed to frequent agitation from winds, being far firmer and longer lived than thoſe which grow in ſhady groves, or hot houſes; both are incapable of aſſimilating to their proper ſubſtance all kinds of food; for fruits are found to taſte of the ſoil, juſt as the urine, and milk, and fleſh, and bones of animals, often give indications of the particular *pabulum* with which they have been fed: both die of old age, from exceſs of hunger or thirſt, from external injuries, from intemperature of weather, or poiſoned food.

Different vegetables require different ſoils, as different animals do different food for their ſupport and well being: aquatics pine away in dry ſandy grounds, and plants which love rocks and barren ſituations, where they imbibe their chief nutriment from the air, become diſeaſed and putrid in rich bogs and ſwamps.

Trees ſhed their leaves as birds do their feathers, and hirſute animals their hair. At particular ſeaſons the juices of vegetables move with fullneſs and vigour; at others they are leſs plentiful, and ſeem to ſtagnate; and in this they reſemble dormice, bats, frogs, and numberleſs other animals of cold blood, which lie torpid and deſtitute of every ſign of life during

during the winter time; the action of the lungs and of the heart being, if any, imperceptibly weak and languid.

Few, if any, animals can exiſt, without a reciprocal ſucceſſion of ſleep and vigilance, and the younger the animal, the greater is its propenſity to ſleep: the ſame alternatives ſeem neceſſary for the health of ſeveral vegetables; a great variety of plants fold up their leaves, and ſeemingly compoſe themſelves to reſt, in the night time, and this diſpoſition for ſleep is more remarkable in young plants than in old ones; nor does it, as might be ſuſpected, depend upon the influence of light or heat, ſince plants in hot-houſes, where the heat is kept at the ſame degree, fold up their leaves at a ſtated time in the evening, and expand them in the morning, whether the light be let in upon them or not. The effects of a cold ungenial ſpring are as remarkable in the retardation of the procreative intercourſes of birds and beaſts, as in the ſtoppage of the leafing of trees, or the flowering of ſhrubs.

I think we may here with propriety attend a little to the uſual compoſition of an animal, which, as I ſaid, differs from a vegetable, in having ~~its~~ parts appropriate to ~~their~~ different functions. The ſeat of life is the blood, and thoſe parts which are neceſſary to its offices; theſe are placed in the centre of the body, in order to maintain around them as equable and conſtant a degree of heat as poſſible, and in order that the circulation may not (as in vegetables) have a long journey ere it reach the extremities: for this circulation being a regular and perpetually-active office, is not like that of a plant, excited only by the warmth of ſpring, and diminiſhed

by

by the chills of approaching winter, but is to maintain itſelf, (and in moderation) notwithſtanding the viciſſitude of ſeaſons. The blood, by having a ſhorter paſſage, is enabled to diſtribute warmth to the extremities in greater abundance, and to perform each revolution in leſs time. There are no internal parts in vegetables which have any manifeſt office of aſſimilating freſh blood to the old; but the various parts neceſſary to this office in animals, are highly elaborate and curious in conſtruction and movement.

Beſide thoſe relating to the blood and its motions (which I conceive as being the principle of life), there is alſo a diſtinct aſſemblage of parts neceſſary to *ſenſation* (and this ſeems the great and capital addition above vegetable life), which is ſeated, not in conjunction with thoſe ſerving to the offices of the blood, but diſtinct and diſtant. It is probable, there is ſomething not unlike the circulation of a fluid from theſe parts to all parts of the body; but whether it be circulated or not, it is occaſionally detached, and when required, in very conſiderable quantities. This communicates the *volition* of the animal to his members; and though, perhaps, it cannot with exact propriety be ſaid to enable them to perform their offices, yet if no intercourſe take place between them and this ſource of ſenſation, they are rather cumberſome loads than uſeful members. It is probable, that all parts of the body have ſmaller portions of this finer fluid at all times reſiding in them (and even, perhaps, have ſmaller collections of it in certain places); but the great magazine which diſtributes as wanted, is in the head, where the ſenſes being more immediately exerciſed, have greater effect upon it, where intelligence of what

paſſes

paſſes is more inſtant, and the various modes of receiving intelligence and impreſſion more active, more concentred, and rapid. It ſhould therefore ſeem, that life, ſuperior, yet allied to that of vegetables, reſides in the heart, and its dependencies; but what elevates animal above vegetable life, is, the faculties attendant on the head. Theſe principles ſeem diſtinct; and, in fact, are in a ſenſe *disjoined* by the diſtance between them, and by more or leſs of a neck, which ſeems to indicate ſomewhat of a partition. In birds this is greatly prolonged; in inſects it is very ſmall and narrow; the creature having the appearance of two parts united by a thread: the effect is, an approach towards ſomewhat of independence in the ſeat of life; for it is well known, that many kinds of inſects will run about after they have loſt their heads, and are very tenacious of life, which does not entirely quit them long after they have loſt the ſeat of ſenſation. The heart, indeed, is ſo ſtrongly endued with life, as to retain it long after it is out of the body (of cold-blooded animals eſpecially): being acted on by heat, it will give tokens of life; or being pricked with a needle it will beat. And I have lately been informed that ſome days after a viper had been embowelled and alſo deprived of its head, life had not totally quitted its body.

I believe we may regard our latter principle as of conſiderable importance, and perhaps not unworthy of forming ſomewhat of a diſtinction in the ranks of life. Animals which have the powers of the thorax, but not the ſenſations of the head, ſeem more allied to vegetation, and leſs approaching to intelligence, even though they poſſeſs locomotive powers. It ſhould ſeem, that this (ſhall I call it *nervous*) fluid is extremely

rapid

rapid in its motion (perhaps like the electric) and very powerful in its ſtimulus. The palſy is a diſeaſe attendant on its ſuſpenſion, whereby ſometimes half the perſon is deprived of ſenſation, and, though affording ſome effects of life, yet dead, while the other half of the perſon is alive. The members, then, are inſtruments, ſervants, to one or other of theſe two great principles, are incapable by themſelves of any kind of life, and are merely animated from other quarters: the loſs of a member does not imply loſs of life, the acquiſition of a member, were it poſſible, would not increaſe life. Could we ſhoot out freſh arms, as trees do branches, it would be not an elevating, but a degrading ſign, ſince nature finiſhes carefully her moſt important works, even in their earlieſt ſtages; while thoſe leſs conſiderable are left in a ſenſe to finiſh themſelves, or at leaſt to be finiſhed by time and duration.

This naturally leads us to a compariſon of Nature's works, as they may be ſaid to be produced by her, into their various ſtations; and that again to her appointed modes of producing them at all. It was the motto of the great HARVEY, *Omnia ex ovo* (all from the egg) and an egg was the ſymbol of creation among the ancient hieroglyphics. With regard to more perfect creatures, I believe it to be juſt; but others contradict the principle.

The earth-worm, the millipedes, the ſea-worm, and many marine inſects, may be multiplied by being cut in pieces; but the freſh-water polypus is noted for its amazing fertility. The ſtructure of a polypus may be compared to the finger of

a glove, open at one end, and closed at the other. The closed end represents the tail, with which the polypus fixes itself; the open end may be compared to the mouth; and if we conceive six or eight small strings issuing from this end, we shall have a proper idea of its arms, which it can erect, lengthen, or contract, at pleasure, like the horns of a snail. This creature is very voracious, and uses its arms to entangle such little animals as come within its reach. It lengthens these arms several inches, spreads them from each other, and thus occupies a large space in the water. These arms, when extended, are as fine as threads of silk, and have a most exquisite degree of feeling. If a small worm happens to get within the sphere of their activity, it is quickly entangled by one of these arms, and; soon after, the others come to its aid; these shortening altogether, the worm is drawn into the animal's mouth, and quickly devoured, colouring the body as it is swallowed. What is most extraordinary remains to be told: when examined with a microscope, several little specks, like buds, appear to pullulate from different parts of the body; these we soon discover to be young polypi, which, like their parent, begin to cast their arms about for prey. Whatever they happen to ensnare is devoured, and gives a colour to the bodies of both. For the food of the little ones passes into the large polypus, and colours its body; and this, in its turn, digests, and swallows its food to pass into theirs. In this manner every polypus has colonies sprouting from its body; and these, even while attached to the parent animal, become parents themselves, having smaller colonies also budding from them. All, at the

same

ſame time, buſily employed in ſeeking for their prey, and the food of any one of them ſerving for the nouriſhment, and circulating through the bodies of all the reſt. This ſociety, however, is every hour diſſolving; thoſe newly produced are ſeen at intervals to leave the body of the large polypus, and become, ſoon after, the head of a beginning colony themſelves.

In this manner the polypus multiplies naturally; but a much readier and ſhorter way to increaſe them, is by cutting them in pieces. Though cut into thouſands of parts, each part ſtill retains its vivacious quality, and ſhortly becomes a diſtinct and a complete polypus: whether cut lengthways, or croſsways, it is all the ſame; this extraordinary creature ſeems a gainer of life by our endeavours to kill it, and multiplies by apparent deſtruction.

To return to our principle, *Omnia ex ovo*:—The ſeeds of plants are in one ſenſe to be regarded as eggs, ſince they contain the embrio plant, much as an egg contains the embrio bird; this ſeed, falling on a ſpot of earth which affords proper warmth, and proper nutriment, opens gradually the plant it contains, and by acceſſion of parts, advances and matures it. There is no *creation* while in the earth, no freſh gift, or principle imparted by it, the whole tranſaction is merely a developement, a bringing to light, an increaſe of what rudiments were depoſited in the ground, under the appearance of ſeed or grain. If we may reaſon by analogy, the earth *hatches* the plant, by furniſhing that kindly proportion of heat which is adapted to its nature; this cauſes the bud to expand, cracks

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the outer caſe which enfolds it, and enables it to ſend forth its roots in queſt of nouriſhment.

The hiſtory of a bird's egg is not ſo far removed as may ſeem at firſt ſight, from that of a ſeed, only as the offspring is different in nature, a different degree of heat is required, and that of the earth in general being too little, the parent bird, with much induſtry and patience, by that of her own body advances the proceſs. That warmth is the principle which promotes life, is clear, ſince between the tropics the ſun's rays hath power ſufficient to hatch many kinds of eggs, where the ſand may hold the heat *conſtantly*; ſo that what it gains by day may not be diſſipated by night, or during any interval or abſence of the heating cauſe. The ſame appears from the inſtance of the Egyptian ovens for hatching chicken, which perform that office to thouſands at a time; but if the heat be ſuſpended, the operation fails: as if it be exceſſive, nature not deſigning ſuch haſte, refuſes to obey its impulſe, and the young life expires. There is no ſuch danger from the parent bird, who does not poſſeſs redundance of heat, and therefore is abſent from her neſt very little time at once, ſcarce ſufficient for the eggs to feel any diminution of temperature. Many birds, natives of warmer climates, when they breed in theſe countries, would abſolutely be ſtarved, were not food ſet cloſe by them, ſo that they need ſcarce quit their neſt to obtain it; and we have accounts of a bird's ſuffering part of her toes to be frozen off, rather than ſuſpend the charge ſhe was engaged in while expecting young.

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The quittance of the young from the egg is its birth: the egg, though ſo long before ſeparated from the parent, was incapable of life, till the warmth of incubation had (as we ſaid of plants) cauſed the internal principles to expand, cracked the outer caſe, which enfolded them, and enabled them to quit it in queſt of nouriſhment; but as ſome ſeeds (perhaps moſt) have a nutrimentitious ſubſtance, which feeds the young leaves while unfit or unable to profit by the food they may receive from the earth, or while they are ſeeking for it, ſo much of the internal contents of an egg is appointed to nouriſh the young bird, before he finds food ſuited to his nature; or leſt any accident ſhould render his early ſtages of life incapable of proper ſupport from other quarters. Life is of ſuch conſequence, as being the great effort of Nature in obedience to Almighty direction, that what is prepared previous to its exiſtence, or at leaſt its appearance, is not only continued during its advance, but alſo after it has attained completion.

There are, indeed, among the inſect tribes, thoſe who undergo ſeveral changes of apparent life, before they acquire their *ultimatum*. At one time they ſeem allied to the waters wherein they are bred and nouriſhed; afterwards they quit their aquatic properties, and fly in the air. Sometimes they appear as butterflies, ſometimes as caterpillars, ſometimes as moths, and there is no little difficulty in determining from their preſent ſtate, what has been their former, or may be their future ſimilitude. But it ſhould ſeem, that nature provides them internal ſupplies, ſufficient for their very limited duration,

duration, as ſome of them ſeem to feed little during certain ſtages of their exiſtence, and others abſolutely exhauſt themſelves, yet receive no ſupport or reſtorative. Life, which thus, as it were, ceaſes and revives, yet originates from eggs; and though eggs, properly ſpeaking, be diſmiſſed after their firſt ſervices, yet the caſes and concealments in which all theſe changes take place, are not totally unlike them, as they hide the proceſs intruſted to their care, and produce, after an apparent death, a life very different from its former properties.

To reduce to ſomewhat of order the progreſs of life, we muſt conſider, 1. That creatures poſſeſs the property of continuing their ſpecies, by means of their ſex. 2. That in conſequence, the major part of creatures furniſh a ſeed which contains the rudiments of their future offspring. 3. This ſeed is developed and forwarded by the operation of heat—in the earth for plants—that of incubation for thoſe creatures which depoſit eggs—that of the body of its parent for ſuch as bring forth their young alive. This laſt is the moſt perfect kind of life; thoſe animals to whom it belongs are of ſuperior ranks, and we know of no degree of life beyond that furniſhed in this method. We may divide theſe ideas of the progreſſes of life into, 1ſt, the *vegetative*; this being all that plants deſire, they diſmiſs their ſeeds or eggs (if we uſe the term) when fit for vegetation; whereas, 2d, the *animal* keeps the vegetating ſeed within itſelf, and being to produce a creature more compleat in its nature and parts, does not exclude her egg till this intent is advanced, and put in a way for happy iſſue; 3d, the *ſuperior animal*, which excludes no egg, but keeps it, till after having

having paſſed the ſtate of vegetative life, and approached towards animal life, it is excluded in full completion: no further change remaining, we deſire only an improving progreſs of what is now produced, to perfect this life to the higheſt ſtation of which its nature is capable.

Theſe ſeem the moſt diſtinct and determinate diviſions, depending on the production of life; there are many ſubdiviſions, and ſome exceptions, which cannot be referred to theſe, ſuch as cuttings, the polypus, &c. already noted. Beſide this, ſome animals, after having excluded their young alive, yet receive them again into a different part of their bodies, by way of completing what was deficient, or of ſtrengthening their natural weakneſs; and this advantage they either quit or receive at their pleaſure.

It is very difficult, in fact ſcarce poſſible, to form any ſimple principles which ſhall include every exiſting variety: I believe the general courſe of nature may be referred to what has been ſaid.

Our remarks on the progreſs of life, have been capable of obſervation, and verification, either by inſpection, or very eaſy inference: but, if it is aſked, by what means do theſe ſeeds acquire the property of producing young? whence get they the embrio they incloſe? the anſwer is not without heſitation. The great Author of nature has appointed two ſexes among his works, whoſe mutual properties are (uſually, but not always) neceſſary. *E. gr.* In plants: Female trees and flowers wither, and die without ſucceſſors, unleſs fertilized by the male flower; which, himſelf, is incapable of conception;

nor is any poſſibility of offspring attached to him, ſolely: Nature has forbad.

It was an experiment well known to the ancients, that female palm-trees yielded no fruit, if prevented commerce with the male palm-tree; when, therefore, he was too diſtant, or otherwiſe ill ſituated, they cut off flowering branches from it, and ſhaking them over the other tree, their duſt or *farina* viſiting the female flowers, produced fruit.

A ſimilar principle is exerciſed by our modern gardeners who wiſh to have early cucumbers (in this fruit, flowers of both ſexes grow on one plant); they cut off the male flowers, and inſert them (turned topſy turvy) into the female flowers, thereby ſprinkling their duſt, and cauſing early impregnation.

This is analogous to the uſual procedure of nature: alone, neither ſex is capable of poſterity; notwithſtanding indications of it in ſome caſes: a female plant produces flowers, but not fruit; or if, in ſome inſtances, fruit, that fruit is incapable of reproducing its like. A hen bird will lay eggs without the company of the cock (eſpecially if within hearing of his ſong); but thoſe eggs will never hatch into young, even if their external appearance be perfect (which is not always); they may be addled, but cannot riſe into life.

Nature has not left to chance, or to uncertainty, whether her numerous families ſhall be continued or not; nay, we know ſhe has fixed principles employed to enſure their perpetuity; but while we admit the fact, and acknowledge the principles, the mode of their action is hidden in obſcurity; our whole knowledge reſolves into what I have hinted; and

doubt

doubt and dilemma embarraſs the moſt ingenious theories, which endeavour further ſolution of the ſecret.

It would be with little propriety, in this aſſembly, that further diſquiſitions were offered on a ſubject hidden from the prying eye of curioſity, though directed by ſkill, and excited by emulation, even if poſſeſſing demonſtration itſelf; but while ſuppoſition is all that can be offered, acknowledged abſence of information is neither reproach nor calamity.

We have ſaid enough on vegetation, to convey ſufficient ideas of its vital progreſs: the rudiments of a plant are expanded by heat, acquire a ſtate of intumeſcence, grow by acceſſion of parts (uſually at firſt derived in the form of nutriment from the pulp incloſed in the caſe), till having opened this caſe, its fibrous roots abſorb the moiſture around them, which becomes the food of the plant, whoſe future efforts are directed to the obtaining a continuance of this aliment.

The progreſs of life in an egg, may require and repay cloſer inſpection.

It would be tedious to deſcribe thoſe parts of an egg which are obvious; its ſhell, its white, and its yolk; but the diſpoſition of theſe is not ſo apparent. Immediately under the ſhell lies that common membrane, or ſkin, which lines it throughout internally, except at the broad end, where is left a little cavity filled with air, which increaſes as the animal within grows larger. This membrane contains two whites (though ſeeming only one), each incloſed in a membrane of its own, one white within the other. In the midſt of all is the yolk, wrapt round, likewiſe, in its own membrane. At

each

each end of this are two ligaments, called *chalazæ*, being white denſe ſubſtances, made from the membranes, and ſerving to keep the white and the yolk in their places. The cicatricula, or ſpeck, where the animal firſt begins to ſhew ſigns of life, is not unlike a vetch, or a lentil, lying on one ſide of the yolk, and within its membrane; the white ſerves as nouriſhment, and the yolk, with its membranes, forms a part of the animal's body. The cicatricula, or ſpeck, is, in impregnated eggs, large; in thoſe laid without the cock, very ſmall. It appears, by the microſcope, to be a kind of bag, containing a tranſparent liquor, in the midſt of which is the embryo, reſembling a compoſition of little threads, which the warmth of incubation enlarges, by varying and liquifying the other fluids contained in the ſhell, and thus preſſing them either into the pores or tubes of theſe threads.

Upon placing eggs in a proper warmth, after ſix hours the vital ſpeck begins to dilate, like the pupil of the eye. The head of the chick is diſtinctly ſeen, with the back-bone, ſomething reſembling a tadpole, floating in its ambient fluid, but as yet ſeeming to aſſume none of the functions of animal life. In about a ſecond ſix hours, the head becomes more plainly viſible, and the vertebræ of the back more eaſily perceivable. Theſe ſigns of preparation for life are increaſed in ſix hours more; and, at the end of twenty-four hours, the ribs begin to take their places, the neck begins to lengthen, and the head to turn to one ſide. At the end of forty hours the great work of life ſeems fairly begun, and the animal plainly appears to move; the back-bone, which is of a whitiſh colour, thickens; the head

is turned ſtill more on one ſide: the firſt rudiments of the eyes begin to appear; the heart beats, and the blood begins already to circulate. In three days the whole body of the chick appears bent; the head, with its two eye-balls, with their different humours, diſtinctly appear; and five other veſicles are ſeen, which unite to form the rudiments of the brain. The outlines alſo of the thighs and wings begin to be ſeen, and the body begins to gather fleſh. After the fifth and ſixth days, the veſſels of the brain begin to be covered over; the wings and thighs lengthen; the belly is cloſed up and tumid; the liver is ſeen within it, very diſtinctly, not yet grown red, but of a very duſky white; both the ventricles of the heart are diſcerned, as if they were two ſeparate hearts, beating diſtinctly; the whole body of the animal is covered over; and the traces of the incipient feathers are already to be ſeen. Hitherto, however, the animal appears as if it had two bodies; the yolk is joined to it by the umbilical veſſels that come from the belly; and is furniſhed with its veſſels, through which the blood circulates, as through the reſt of the body of the chick, making a bulk greater than that of the animal itſelf. But towards the end of incubation, the umbilical veſſels ſhorten the yolk, and with it the inteſtines are thruſt up into the body of the chick, by the action of the muſcles of the belly; and the two bodies are thus formed into one. During this ſtate, all the organs are found to perform their ſecretions: the bile is found to be ſeparated, as in grown animals; but is fluid, tranſparent, and without bitterneſs: and the chick then alſo appears to have lungs. On the eleventh, the heart,

which

which hitherto appeared divided, begins to unite; its arteries join into it, like the fingers into the palm of the hand. All theſe appearances only come more into view, becauſe, the ſecreted fluids deepening in colour, their operations and circulations are more diſtinctly ſeen. For ſome time before it is able to break the ſhell, the animal is heard to chirrup, receiving air enough for this purpoſe, from that cavity which lies between the membrane and the ſhell. At length, upon the twentieth day, in ſome birds ſooner, and later in others, the incloſed animal breaks, with its beak, the ſhell within which it has been confined; and, by repeated efforts (uſually aſſiſted by the parent hen), at laſt procures its enlargement.

From this little hiſtory we perceive, that thoſe parts which are moſt conducive to life are firſt begun: the head, and the back-bone, which no doubt incloſe the brain, and the ſpinal marrow, though both are too limpid to be diſcerned, are the firſt that are ſeen to exiſt; the beating of the heart is perceived ſoon after: the leſs noble parts ſeem to ſpring from theſe; the wings, the thighs, the feet, and, laſtly, the bill.

Whatever, therefore, the animal has double, or whatever it can live without the uſe of, theſe are lateſt in production: nature firſt ſedulouſly applying to the formation of the nobler organs, without which life would be of ſhort continuance, or would be begun in vain.

Such is the account of thoſe who have moſt ſedulouſly traced the progreſs of vivification in this department: And (as it ſtrikes me) on the ſame principles is the yet higher degree of life communicated, and advanced; but as ſuperior degrees require ſuperior care, that care is entruſted only to the parent,

parent, who does not produce her young till their life is further advanced.

That there ſhould be ſomewhat of a different mechaniſm employed to convey nouriſhment to a young life while forming part of its parent, from what is appointed to the egg, is very natural; and when this has been conſidered, the hiſtory of one may ſuperſede the relation of the other.

I have hinted, that animals produce their young in various degrees of perfection, ſome ſo tender that they again retire to their parent's body, ſome with little power of motion, ſome without ſight (as moſt, if not all beaſts of prey), and, in ſhort, all have a ſomewhat to acquire, whether it be feathers, or hair, or the uſe of faculties; all have ſome deficiencies, though not of eſſentials to life.

If we trace this donation (life) from its beginning, we find many changes ere it arrives at maturity; birds ſhed their feathers, and acquire freſh plumage; and this ſo varied from their former, that they are totally new birds, ſo far as plumage goes; their colours are very greatly heightened, commonly differently placed; and a conſpicuous advance is viſible. Quadrupeds are perhaps leſs changed in their colours, yet receive hair of ſuperior quality, and other advantages. Reptiles change their ſkins, and inſects their natures.

What has been ſaid, naturally divides animal life into, 1ſt, the OVIPAROUS, or that evidently imparted by eggs; 2d, the VIVIPAROUS, or that of young produced alive. To the firſt we refer birds, inſects, fiſh, &c. certainly the major part of lives. To the latter, ſome reptiles, quadrupeds, and mankind.

The wiſe and the fooliſh, talents and ſtupidity, have one common origin; nor is it poſſible to predict which ſhall eventually occur. All we know is, that certain cauſes produce certain effects; that principles will have their force, and are infinitely variable. Only obſerve the diverſity in the ſhapes and colours of the eggs of birds: one ſhould think an oval form incapable of ſuch mutation, here being ſomewhat rounded, there ſomewhat lengthened; here raiſed, there flatted; no doubt theſe very forms have relation to the future offspring; but what, who can tell! No doubt they contain that preciſe ſhape which is beſt adapted to the make of the incloſed fœtus; but what determines them to that particular ſhape, we know not; what affinity their ſpots have to the parent, or to its young, we are ignorant. It cannot be merely as marks, ſince ſome birds do not know their own eggs (though perhaps moſt do) and eggs neglected by their parent yet have ſpots.

There reigns much obſcurity and uncertainty over whatever principles emerge into life; nor are the ſuſtenance and continuance of life much leſs embarraſſed. We ſee effects, but their cauſes eſcape us; we deſire to examine the Why, and the Wherefore, but our diſquiſitions, like our faculties, are limited; and we find ourſelves circumſcribed to an acquaintance with the reſult, without power to analyſe the combination. This will further appear, the more cloſely we inſpect animated compoſition, the more intenſely we bend our inquiring attention; as will be proved in our enſuing Diſcourſe.

LECTURE

LECTURE V.

WE have, I ſuppoſe, all of us heard of thoſe ſceptical principles, which refuſed to believe what they could not account for; which denied a conſequence, unleſs acquainted with the previous ſteps which led to it; which thought every combination, its relations, its degrees, its importance, its ſubſequences, *muſt* be explained and demonſtrated before any dependance might be placed upon it. That thoſe infected with theſe principles ſhould doubt their own exiſtence, is no unnatural event; on ſuch principles all is doubt; for, ſay they, our ſenſes are our only means of information, but theſe are conſtantly liable to deception; how ſhould we truſt them? Such will ever be the reſult of graſping at too much; we are incapable of knowledge beyond limited degrees, within which we find ample ſcope for ingenuity and diligence, and have little occaſion to ſigh for other worlds to conquer; ſo much yet remains not only unconquered, but undiſcovered.

There is no one in this auditory, I preſume, who doubts of his exiſtence, or his preſence, who requires additional evidence to prove himſelf alive; yet if aſked, what is life? a very impotent anſwer is all human ſkill can offer. Do we know the firſt principle whereby we lift up our hands? whereby ſight or hearing are performed? whereby, in fact, any one property

of

of life is exerted? If then the moving cauſe of theſe parts, or actions, of life is unknown, how ſhall we determine on their combination? If, when taken ſeparately, they not only embarraſs but elude our reſearches, upon what principles ſhall we define the aggregate? That power, which, though actuating the whole, is neither; which, if deprived of any one, ſuffers no real diminution; which performs, independently of our attention (often contrary to our will), many important functions, and yet is ſo allied, ſo indiſpenſable to our nature, that with every part neceſſary for every function, with no perceptible deficiency, yet ceaſes. Here, a man lives without ſight, or hearing, or taſting, without arms or legs, without ears or noſe; there, is a body poſſeſſing all theſe, but inanimate; and we are reduced to the neceſſity of confeſſing that one is—Life; the other—Death; and here terminates in effect our knowledge: we perceive in one caſe an undefinable ſomething, of which the other is deſtitute; and this abſence or preſence is all which determines our judgments.

But life is not leſs real, becauſe beyond our comprehenſion; we are equally active, whatever be the cauſe of our activity; and though the mode of its operation be concealed, yet the effects of, and the preparations for it, are evident; and will now occupy our attention.

The ranks, and the progreſs of life we have treated; the maintenance and ſupport of life well deſerve our inquiry. I ſhall not here advert regularly to the diſtinctions of life; but ſhall aſſume, that in ourſelves we poſſeſs the moſt elevated ſtation among creatures, and ſhall therefore conſider the human frame

frame as the beſt ſpecimen of what is connected with, or neceſſary to, animated exiſtence.

An animal body may be conſidered as compoſed of ſolids and fluids; fleſh, in a ſenſe, partakes of both. The bones are ſolids, but not all equally ſolid, nor all parts of the ſame bone; nay, ſolid as a bone appears, its inſide is ſoft, and very unlike its outſide. Bones ſolid throughout are rare; we are indeed told that a lion's leg bone is ſolid, and ſo hard that it will ſtrike fire like a flint; but in general, bones have a circulation of nutritive juice moving in them, and many may well be regarded as oſſeous tubes. Let us inquire a moment into the deſign of Nature in the conſtruction of theſe parts. A bone is formed for ſtrength, and ſupport to the fabric which contains it; it muſt therefore poſſeſs theſe properties in itſelf, *i. e.* it muſt be a denſe, firm, compact, ſubſtance; now, if too denſe and compact, it will be heavy beyond the proportion of ſtrength in the creature; but its weight may be diminiſhed by hollowneſs, and this hollowneſs may afford advantage to inſert an oily matter which may correct the danger of its becoming too dry; may moiſten, and nouriſh it: to its nouriſhment alſo may contribute the free admiſſion of proper juices into its ſofter and more porous parts, which may alſo connect with its marrow. But in order to ſupport the body throughout, there is requiſite a ſyſtem of bones; theſe muſt connect together, and that, ſo as to permit motion at the parts connected. Two hard ſubſtances *grating* againſt each other, by their mutual violence may be exceedingly detrimental; this muſt be prevented, by coating each of them, where they unite, with a ſubſtance

ſmooth

ſmooth and ſoft, yet tenacious, and this lubricated with oil. To theſe precautions muſt be added that of accurate *fitting* the receiver to the received.

This idea ſeems principal in the bones of the leg and of the arm; but as little motion (comparatively) and much ſtrength are wanting in theſe parts, their bones are of great length, and few joints; whereas, the back requiring much motion, very free, and in all directions, many joints are employed; very different ſhape and conſtruction is uſed, and very great care in the article of fitting. All the vertebræ of the back are not of the ſame ſize, or ſhape; thoſe in the upper part of the column are calculated to give freedom to movements of the head; and centrally, through the whole ſpine, runs a channel of moſt delicate marrow: injuries here are fatal; it is therefore defended by theſe bones as a fortification.

This opens another advantage of bones, they are a kind of defenſative armour, protecting the moſt important parts. This is clearly the office of the ribs; they ſurround, and defend the vitals, yet, being elaſtic, are moved by the motions neceſſary to breathing: their forms and bendings are alſo adapted to this, nor are they extended beyond what neceſſity requires. Very different are the bones which guard the head; they require no alternate extenſion and retraction, therefore are not elaſtic; the contents are ſubject to little variation, neither are the bones; *ſecurity* is here the leading idea; bones therefore cover the whole, only perforated where the exerciſe of the ſenſes require it.

Bones

Bones afford fixed points for the attachment of muſcles, which are to move the whole frame; muſcles are compoſed of fleſhy fibres, which run in various directions, ſometimes the longeſt direction of the muſcle, ſometimes obliquely, or, like the beards of a feather; theſe fibres are connected together, are capable of ſhortening (by ſwelling) and of comparative lengthening (by ſubſidence of their ſwellings); if a muſcle ſhortens, it affects the points of its origin and termination (conſequently the joint between them, if there be one); to return them to their former ſtations, is the office of an antagoniſt muſcle. Take an arm, for inſtance, this is not like a pendulum, which having been drawn two feet out of its perpendicular one way, will of courſe ſwing two feet the other way; but, if having drawn my arm two feet behind me, I wiſh to advance it two feet before me, I muſt employ a totally different ſet of muſcles for the two motions. Thus, as by a kind of double ſets of ſprings, acting alternately on each other, the bones are drawn either way, according to the inclination of the perſon: as I have elſewhere ſtated it. The number of muſcles acting in the body is very great; thoſe which play on its ſurface only, are calculated at ninety-ſix.

The muſcles have much of ſolidity in them, but leſt they ſhould become ſtiff and rigid, they are attended by various depoſits of a very different ſubſtance (fat) in which moiſture has a principal ſhare.

The other component principle we mentioned, was fluid; and this we well know circulates in our veins, and this circulation is of the utmoſt importance. The fluid appointed to our compoſition is not left at large, but confined,

and conducted in a regular manner. It iſſues from the heart in a ſtream of conſiderable dimenſions; this is ſubdivided, in order to viſit every part of the frame, in *arteries*, upwards, downwards, around, whoſe extreme ramifications are ſo minute, that the eye is unable to diſcern them. By the help of glaſſes we know, that where theſe tubes terminate, there the veins originate; which from ſmall beginnings, by conjunction are enlarged, till at their diſcharge into the heart, they nearly equal the contents of their correſponding arteries.

Thus, in few words, have we hinted at theſe wonderful phenomena; my auditory are not ignorant that many folio volumes have been written, and certainly will be written on the ſubject: they will therefore expect hints only on a ſubject ſo copious and extenſive. Take any one part, it is more than enough for an evening; let us exemplify this in conſidering the variety compriſed in the arm. The long and ſingle bone from the ſhoulder to the elbow—its gentle bend—the double bone from the elbow to the wriſt—the bendings of theſe bones—their inſertions—the various joints of the hand—the fingers—the muſcles which from the ſhoulder run all down the arm--in ſome places more fleſhy, and thicker—in others thinner:---But leſt ſo many, though thinned, ſhould take up too much room, they change when they get to the wriſt, into another ſubſtance of a more ſtringy nature, and theſe ſtrings proceed to the very extremity of the fingers;---and in double ſets;---one to cloſe the hand, another to open it;---one to turn the hand downward, another to turn it upward; this bends the arm, that extends it: If to this we add, the idea of what various

apparent

apparent matter compoſes the arm, muſcular fibre---fat---tendons---glands---and ſo forth: the nature of its veins---their ramifications (which on the back of the hand is proverbially various)---the nerves---the nails---and a long ſtring of *et ceteras*, were we to examine all theſe, when ſhould we cloſe? Aware of this, I would rather direct your thoughts to the variety adopted by nature, in conſtructing theſe principal parts, according to the ſituations and manners of her creatures. The bones of a quadruped (a horſe) are not like thoſe of man; his large thighs require great props, and they have them: different in number, in form, and connection, from thoſe of the human ſpecies. Conſider a bird, different from both; conſider a reptile (a ſnake), all vertebræ from his neck to his tail; conſider a fiſh, not only in the general idea, but the form of his bones.

We find one leading principle branching out into almoſt infinite accommodations; moſt have ribs, ſome more, ſome fewer: (in ſerpents are two ribs to each joint, which make nearly three hundred in all) becauſe defence is indiſpenſible to the vital parts; alſo vertebræ, of many various forms, gradually changing, nothing harſh or ſudden: a triangular form, little by little, becomes flat (as an eel's back-bone) or is otherwiſe varied. The idea of protection too, never is forſaken in the head; which, of whatever ſhape it be, round or flat, yet has its bony armour. Such is the general rule of nature; but, as if reſolved to puzzle that creature who would peculiarly arrogate wiſdom, ſhe has many exceptions. The tortoiſe, covered with a ſhell, has no vertebræ yet is a quadruped; ſhell-fiſh none, nor, properly ſpeaking, bones. Many kinds of marine ani-

mals have no heads, though they have mouths: Reptiles have no legs, or arms, and thus, were we inclined to name every part of our bodies, ſome animal or other may be found who has nothing anſwering to it, but lives without its functions. If we compare the fleſh of animals with the human, or with each other, there is equal variety; that of beaſts, that of fowl, that of fiſh, of ſhell-fiſh, of reptiles, of inſects. If we compare bloods, ſome are hot, ſome cold, ſome red, ſome white, ſome very little like blood, ſome not at all. Yet I think it may fairly be preſumed, that a circulation of ſome fluid, under ſome modification or other, is always actually maintained.

Moreover, as to the number of parts neceſſary to life, nature is equally perplexing. One head, I believe, is the general donation, but this head, furniſhed in different animals with unequal number of parts (as we have hinted in the inſtance of eyes). One heart is common; but certain of the inſect tribes have many: and how many legs? hence denominated *centipes* and *millipedes* (hundred-legged and thouſand-legged). We have only one pair of lungs, caterpillars have eighteen, other inſects ten or a dozen. I believe an argument might be raiſed, from the uſual courſe of nature in giving but one head, to prove the comparative ſuperior importance of that part, for nature is ever frugal of her important gifts.

It is impoſſible to convey by deſcription, any adequate idea of the wonderful contrivances ſituated within us, and inſpection of the parts is not propoſed in this aſſembly. I ſhall therefore introduce merely a few looſe hints which exemplify great contrivance, yet may eaſily be comprehended while I ſpeak.

To

To what I have ſaid on the bones, I ſhall only ſugeſt, that hard as they ſeem, they certainly muſt have a circulation through them, ſince even the teeth are obſerved in conſumptive perſons to change their colour and appearance. Broken bones alſo, furniſh a matter which, from gelatinous ſoftneſs, gradually hardens to oſſification: and ſometimes this matter abounds in a hurtful degree.

To the account given of the blood, I wiſh to add, that it is *forcibly* driven by the heart into the arteries; here conſider the power of the heart, and its perpetuity, no ceſſation, no pauſe; it has been ordered to its office, and conſtantly obeys: but when the blood is in arteries diſtant from the heart, how is it further impelled? By the current which follows, and alſo, probably, by a muſcular motion in the arteries themſelves. An artery is not a ſingle tube, but compoſed of four ſtrong coats, whoſe fibres are not all in the ſame direction, but act on each other: I ſay, of four different teguments or coats, thereby being greatly ſtrengthened; for ſhould an artery, of conſiderable dimenſions burſt, farewell life! Veins are alſo compoſed of four coats, but thin, weak, and comparatively feeble: For as they return the blood to the heart, they have no impulſe to provide againſt, and ſuſtain no effort. But they are liable to another danger, that is, leſt the blood (eſpecially when aſcending) ſhould attempt to return back in its channel; and this is prevented by what anatomiſts term *valves*, which, opening only the right way, cloſe up the entrance againſt the returning fluid.

Man is placed on a globe, ſurrounded every where with a fluid; this may well be expected to penetrate him intimately,

to

to form part of his compoſition, and ſo it does; but in order that the greateſt advantage to him may ariſe from this element, it is neceſſary that it be appointed to ſpecific purpoſes; that parts be adapted to direct and regulate it in the attainments of ſuch purpoſes; and that after having diſcharged its office, it may give place to freſh ſupplies, fraught with freſh vigour. Reſpiration is among the moſt neceſſary functions of life; ſuſpend it, life ſtagnates; deſtroy it, life expires: upon reſpiration depends the circulation of the blood, and upon the circulation of the blood all the ſecretions (many of them being diſcharges of what is hurtful to that fluid) alſo the converſion of nutritious ſubſtances into part of the animal œconomy, the ſupply of ſpirits to the head, and other important offices of life.

Reſpiration is, we know, performed by internal parts appointed to that purpoſe; theſe, by being capable of dilatation and contraction, are fitted to receive freſh air, which they inhale, and to emit what has done its duty. This operation is gentle, little by little: were all the air in the lungs ſuddenly changed, it would chill the blood, and ſtagnate it; as, were it never changed, the blood would corrupt; the air of the lungs cools the blood, and maintains a due temperature; beſides what effects have been ſuppoſed to ariſe from its weight and ſpring, in promoting the circulation. The veins return the circulated blood to the heart, which ſends it to the lungs, for the benefit of air, then regains it from the lungs, before it recommences its courſe.

But

But a man cannot live upon air, for air is incapable of being converted into blood; though an ingredient, yet it is only one ingredient; but renewals of blood are neceſſary, and this is to be obtained from food. I am not willing to allow, that "life conſiſts in eating and drinking," but I am clearly of opinion it ſubſiſts by thoſe offices; and though I have not myſelf the honour of a "portly belly," nor perhaps envy thoſe who have, yet have I true Engliſh veneration for beef and pudding.

DIGESTION is of the greateſt conſequence to the ſupport of life; many different opinions have been maintained on its progreſs, it ſeems to me to be, an union of various principles, modified according to the ſubject. The great muſcular ſtrength of the ſtomach (or gizzard) in ſome kinds of birds, point out *compreſſure*, as one principle; and the peculiar motion of theſe parts ſuggeſt attrition, or grinding, as another principle: and this ſeems analogous to the food of ſuch birds, which is grain covered by ſeveral coats, the huſks of this grain are to be beat off before the pulp or nutriment contained in them can be come at (which is not *always* done before it is ſwallowed) and this nutriment itſelf requires comminution to liberate its nutritive parts.

But the ſtomach alſo yields a peculiar fluid proper to itſelf, whoſe office is to forward digeſtion, to penetrate the food, and diſſolve it, and alſo to promote a fermentation. Some birds who live on fiſh, have this power ſo ſtrongly, that when they have caught a fiſh too large to enter their ſtomach, while yet in the gullet, it is gradually diſſolved at the head (next the ſtomach, for ſo they always ſwallow them) while the body, &c.

are freſh. By this rapid digeſtion in the ſpace of a couple of hours, the bird is as hungry as ever. The oſtrich, you may have heard, has had the reputation of digeſting iron; this is falſe: for though the fool of a bird will ſwallow any thing, even a hot coal, yet he cannot digeſt it; but he certainly has powers adapted to the productions of the barren and ſandy deſarts of which he is native: theſe cannot but be dry and harſh, and the ſtomach of the oſtrich is furniſhed with glands which afford a ſtrongly digeſtive juice, whoſe penetration may ſeparate the parts even of ſuch dry and harſh ſubſtances, but in which metals are inſoluble.

Warmth ſeems neceſſary to the office of digeſtion; but though by this principle alone very ſurpriſing effects have been produced (even to the ſolution of bones, horn, and other hard ſubſtances) yet theſe effects follow only under certain circumſtances (ſuch as the excluſion of air, &c.) which are not uſually attendant on digeſtion; on the contrary, I ſuſpect, that air has ſome ſhare in this office, by its acid property contributing to the ſolution of the contents of the ſtomach; as we not infrequently hear perſons of little appetite expreſs themſelves as much invigorated, ſimply by the operation of a keener air. Let us unite theſe principles.

To promote, at leaſt, if not to occaſion, that fermentation of food, which is a leading principle in digeſtion, warmth is neceſſary, ſo is the juice furniſhed by the ſtomach, whoſe duty ſeems to be this very act, and whoſe properties are ſo adapted to it, that if food be wanting, it will diſſolve the coats of the ſtomach itſelf, and even retain its activity after the extinc-

tion

tion of life, as has been verified by obſervation in caſes of ſudden death. To theſe we may add a kind of attrition or compreſſure, whereby the food is reduced to a very pulp, and all its juices extracted, and ſeparated.

The ſtomach is a membranous bag, capable of extenſion, and contraction; at its further end is a paſſage not very open, nor altogether at the *bottom* (*i. e.* the loweſt part) of the ſtomach, but elevated; over this paſſes the food now liquidated, and turned to *chyle*; here begins the canal of the inteſtines, which are replete with exceeding minute orifices, each of which draws a ſomewhat nutritive from the paſſing chyle, till what remains being refuſe, and incapable of furniſhing further aliment, is protruded throughout the whole canal, and diſcharged. The motion of the bowels, by which this is effected, is highly curious, and ſomewhat reſembles the creeping of a worm. Nor ſhould it be forgot, that the gall contributes to the eaſier paſſage of the contents of the bowels, in thoſe creatures who have gall-bladders.

This ſeems the regular courſe of digeſtion; but there are creatures who return by their mouth what they do not digeſt; and many birds of prey thus return the ſkins or feathers, &c. of the animals they have devoured, rolled up in little pellets. Some kind of birds, as wood-cocks, ſnipes, &c. which feed on worms, have never any thing in their bowels; their food melts, and is quickly abſorbed. And ſome creatures have no viſible ejecting paſſage; but their food is ſuppoſed to paſs the pores of their bodies.

Animals

Animals which feed on herbage (as oxen) are long in digeſtion; they fill their firſt ſtomach (which may be thought anſwering to the craw of birds) and by a gentle compreſſure force up a part of its contents (and I believe not that part laſt ſwallowed); this they grind again, by which being mixed with their ſaliva it becomes more liquid, as well as finer, it now paſſes into another ſtomach, a third, and even a fourth, that it may be prepared as much as poſſible, to give out thoſe of its particles which are adapted to become fleſh. Of digeſtion, then, as of all other functions, there are various degrees: here rapid, and almoſt inſtantaneous; there ſlow and very gradual; requiring repeated preparation. This laſt faculty has been known in the human kind, but is very extraordinary.

I think the cauſes of *hunger* are pretty evident from what has been ſaid: Nature well knew, that the higher, or ſuſtaining, operations of life, were not fit to be truſted to the individual himſelf, ſhe therefore has furniſhed the ſtomach with a power of perpetual remonſtrance, of exclaiming *neceſſity!* in a manner not to be ſuppreſſed or ſilenced, but by adequate ſatisfaction. It is true, and very remarkable, that deſtructive creatures, as well beaſts as birds, can ſupport faſting a long time (an eagle when confined has been known to faſt three weeks at leaſt, and a rattle-ſnake ſent over to England had no food during two or three months, yet was when diſſected very fat; it is ſaid indeed they will live for years without food, as leeches will in glaſſes), nature having endowed theſe beings with powers ſuitable to the probabilities of their ways of life.

As

As theſe live upon accidental carnage, when at liberty, nature has contracted their ſtomachs, to ſuit them for their precarious way of living; and kindly, while it abridges the banquet, leſſens the neceſſity of providing for it. The meaner tribes of animals are ſtill more capable of ſuſtaining life without food, many of them remaining in a ſtate of torpid indifference till their prey approaches, when they jump upon and ſeize it. In this manner, the ſnake, or the ſpider, continue, for ſeveral months together, to ſubſiſt upon a ſingle meal; and ſome of the butterfly kinds live upon little or nothing.

But this is not the caſe with man, whoſe wants are conſtant, as well as preſſing. We are told indeed of CHARLES XII. of Sweden, that he abſolutely faſted eight days without injury; and we know that the American Indians, when journeying, if they fail of beaſts of chace, are long without food, and by pills of tobacco contrive to ſtupify thoſe wants they cannot ſupply.

Voluntary abſtinence may be much more eaſily ſupported than conſtrained hunger. Man is ſaid to live without food for ſeven days; which is the uſual limit aſſigned him: and, perhaps, in a ſtate of conſtraint, is the longeſt time he ſurvives the want of it. But, in caſes of voluntary abſtinence, of ſickneſs, or ſleeping, he has been known to live much longer.

In the records of the Tower, there is an account of a Scotchman, impriſoned for felony, who, for the ſpace of ſix weeks, took not the leaſt ſuſtenance, being exactly watched during the whole time; and for this he received the king's pardon.

Habit is indeed very powerful, and may accompliſh much, eſpecially where little exerciſe or perſpiration takes place; but in general, thoſe who labour, are quickly ſpent if deprived of food; whether their labour be mental or bodily, for, intenſe thought diſſipates the finer ſpirits at an extravagant rate, and perhaps ſooner produces inanity and weakneſs than common labour. This is one of the unaccountables attending the union of body and mind.

Perſpiration is ſenſible or inſenſible; the proportion of the latter is aſſerted as much beyond that of the former, and has very great influence on health. I ſhall not enlarge on this article, but it muſt be included, becauſe, I think it not improper, to remark how many, and thoſe the moſt important, the indiſpenſible functions of life, are continually proceeding independent of any ſpecific act of our own, or of any part taken by us to promote and maintain them. The heart beats, the blood circulates, the bowels move, the various ſecretions take place throughout the body, and from the ſurface of the body is perpetually iſſuing an atmoſphere of perſpiration. We breathe, we digeſt, whether waking or ſleeping, whether intending, or void of the intent, what remains to complete the animal functions of life? what can aſſiduity add to theſe functions?—merely the ſupplying that appetite which craves for the ſupport of the whole. So much, in fact, has nature done! So little has ſhe left to do! Perſonal ſafety and maintenance alone falls upon the individual to provide, all neceſſary powers of life are provided.

There remains to notice, the covering which nature imparts to her offspring; it is not eaſy to prove, that, in this reſpect, ſhe has taken equal care of man as of brutes, becauſe in the preſent ſtate of ſociety there is variety of reaſons why we are not expoſed in a naked ſtate, to the viciſſitudes of the ſeaſons. It is true, that in ſome parts of the globe the inhabitants are naked; but it is alſo true, that they have clothes of ſome kind, and alſo habitations: nor do I know of any race of men who are by any means comparable in natural clothing to the generality of creatures. At the ſame time it muſt be allowed, that our moſt important parts have at once clothing and ornament, for ſuch ſurely is the hair beſtowed on the head; which, in all ages and places, has had peculiar attention paid it, though on different fanciful principles. As Europeans we decorate the hair of our head, and ſhave that of the beard; the Turks venerate that of the beard, and ſhave that of the head; the North American Indians pull out by the roots what grows on the face, and ſo artfully, that many perſons have aſſerted they had naturally no beards (but this is not true); while the Chineſe is by law obliged to deprive himſelf of all, except what little he preſerves to form into a *queue*.

Is not hair a kind of vegetable growing on an animal body, in the form of a hollow tube, having its proper root, veins, and fibres, but differing from other vegetables, in having no viſible means of propagating its ſpecies, but growing more or leſs apparently all over the ſkin; and, *poſſibly*, in a ſtate of wildneſs, capable of ſerving as ſomewhat of a covering? I ſay poſſibly, for as we find other excrementitious parts capable

of extenſion much beyond what civil life ſuppoſes, why not this? Our nails, for inſtance, on the hands and feet, if long left to grow, would almoſt equal (in appearance, not in ſtrength) the talons of birds, and the hoofs of quadrupeds. The hair of the head is capable of growing down to the heels; and ſome nations have been ſaid to wear it trailing on the ground.

Hair is of very different qualities, as well as colours, and not a little influenced by climate. Its differences might be inſtanced in—the briſtles of the hog kind, the delicate ſoftneſs of camel's hair, the fur of many quadrupeds, the wool of ſheep, which is but a kind of hair, human hair, &c. Human hair becomes woolly in the negro, as ſheep's wool becomes hairy, like that of a goat between the tropics; the hair of moſt animals in the diſtrict of Angora in Syria becomes exceedingly fine and ſilky, and of great length; the Angora goat is famous; and the rabbits of that country train after them a great burden of fur, at the time of their ſhedding it. As to the colour of hair (as of feathers), it is totally unaccounted for, and influenced by cauſes which eſcape us. We have indeed, on the article of feathers, information that the South American Indians change the colours of thoſe which they wiſh to grow on a certain kind of parrot or mackaw, by taking the bird very young, pulling out its preſent feathers, and, by dropping the blood of a peculiar ſpecies of frog on the part ſo denuded, the following feathers from yellow become red. This is the only inſtance of artificial management on a living ſubject with which I am acquainted (the art of breeding particular coloured birds is another affair), but we know, that a linnet confined in a cage, after a year or two, loſes

loſes the beautiful dapplings of red upon his head; and certain kinds of food greatly injure the colours of plumage in other birds.

Hair and feathers are given as warm and ſubſtantial cloth-ing to their poſſeſſors: that furs are warm, is well known to the ladies, who of late have greatly adopted them: that fea-thers are warm any one may be convinced, who in winter time examines any kind of wild bird: to inſtance in a wood pigeon, becauſe I happened to examine one but yeſterday. Under the outer coat of feathers which are much more com-pact and numerous than they ſeem, are other ranks, of the ſame nature, but ſmaller, and intermixed next the body with a profuſion of down, thickly ſet. Aquatic birds are often on the ocean days together: what thick coverings of feathers muſt they have to keep out the water! Recollect alſo, that ſome birds in their plumage appear of great ſize, but when plucked this apparent bulk is much diminiſhed. Feathers are, ſome ſmooth, ſtiff, and ſtrong; ſome feeble, ſhivering, and bending; according to their deſigned uſe; whether for flight, or merely for covering. In general I may ſay, a feather is a compoſition of other feathers, ſo arranged as to form one whole; and each of theſe ſmaller feathers has its veſſels and its varieties.

It muſt be owned, after what has been ſaid, that man has naturally no clothing: and perhaps this is the very diſtinction originally intended; "naked but not aſhamed," implies a ſtate of control and dominion over inferior creatures, whoſe arms might be uſed for miſchief on equals if without defence,

but

but who were awed by a ſuperior. It implies, alſo, an equality of ſeaſons, of atmoſpheric temperature, and many other advantages, alas! too juſtly forfeited. Without defence, without covering, without dwelling, was the deſcription of that maſterpiece of creation, the *remnant* of whoſe rational powers, has invented numerous ſubſtitutes for theſe natural advantages.

Feathers, and hair, are inſerted into, or grow upon the ſkin; which furniſhes the nutriment proper to each, and which has been ſaid, by the dimenſions of its pores to determine its orifices to the production of wool, or of hair. I do not aſſert this; but it may be ſo. The whole body is ſurrounded by ſkin, and all parts of the body have ſomewhat ſimilar, though in many caſes of very great fineneſs. The external (human) ſkin is compoſed of three layers; the outermoſt (the Cuticula) greatly reſembling in compoſition the ſcales of a fiſh, forming a firm, compact, yet elaſtic, and flexible covering; the ſecond (the Cutis) is the ſeat of termination to an amazing extenſion of nerves, which contribute to ſenſation, being nearer the depoſitum of fat which ſurrounds the body. Between theſe is a layer of a ſofter nature than the others (the Reticula mucoſa).

As quadrupeds are moſtly clothed with hair, I imagine their ſkins differ by greater thickneſs, and abundance of that moiſture which nouriſhes and promotes the growth of hair: the ſkins of birds are, probably, more oily, and of larger pores. Different climates and ſeaſons change the hair and feathers;

during the ſnows of winter in the North, moſt animals are ſnow white, and recover their other colours with the advances of ſpring. As to grey, or ſilver, hairs I need ſay nothing. Only that I knew a lady who having been frightened over night, was entirely grey headed next morning.

There is a peculiarity attending reptiles, and ſome other creatures, that of caſting their ſkins; ſome annually, others often, which is not eaſily accounted for. Silk-worms ſhed their ſkins about every fortnight, poſſibly becauſe they are not ſufficiently elaſtic to ſtretch to the ſize wanted by the animal for growth (the human ſkin will ſtretch to any ſize, but will not return to its firſt dimenſions); many inſects the ſame, and ſo perfect are their *left off coverings* as eaſily to be taken by the unaccuſtomed eye for the living animal. Shells are in a manner the ſkins of ſome kinds of fiſh, which ſeveral caſt annually, or occaſionally. When we conſider it, there ſeems ſomething more wonderful ſtill in the caſting of bones than of the ſkin; yet this in the inſtance of the teeth is notorious, not only in the human ſpecies, but in oxen, ſheep, &c.

What has hitherto employed our thoughts, ſeem to be thoſe neceſſary principles to life, without which it could not be maintained; their application is varied by circumſtances, but the principles themſelves are permanent. I might inſtance variation of circumſtances in poſition, as erect or prone; this relates to form, and form as determined by the ſtructure of the ſolids: whereas, what relates to digeſtion, conſequently to food,

food, is determined by the fitneſs and powers of the parts deſtined to that office.

To treat firſt of the latter, *i. e. food.* In relation to this principle we may conſider the tribes of creatures as, CARNIVOROUS, or fleſh-eaters; PISCIVOROUS, or fiſh-eaters; FRUCTIVOROUS, or fruit-eaters; GRAMINIVOROUS, or grain-eaters; OMNIVOROUS, or thoſe who devour whatever they find. Among the firſt we reckon, birds and beaſts of prey, whoſe ferocity cannot be ſatisfied but with blood; whoſe thirſt is extreme, and uſually ſlaked in the blood of the prey, before their hunger excites them to devour its fleſh. This is notoriouſly the caſe with the tiger, who, though he *will* drink water, yet delights in blood; and buries his head up to his eyes, in the body of his victim. The lion is ſaid to be always in a fever of thirſt; and little ſhort of ſuch fever are perhaps all wild animals, expoſed to ſuch ſultry heats as thoſe of African deſarts. Birds of prey ſeem not immediately formed for ſucking, and yet it may be doubted, whether what reliſh they enjoy is not rather that of the blood than that of the fleſh. This ſeems alſo the delight of the ſpider, who often, if not always, leaves the carcaſe from which he has extracted the vital fluid. On the contrary, reptiles ſeem rather to ſwallow than to feed; they neither ſuck the blood, nor devour the fleſh; but having prepared their prey by covering it with a ſlippery gluten for its readier paſſage, they paſs it down their throats, and wait its digeſtion. In the ſtate of debility conſequent on this tranſaction, they are eaſily killed; incapable of eſcape

or of reſiſtance, they entirely ceaſe to be formidable. The Beaſts and the Birds we named are creatures of warm blood; but ſerpents are of cold blood. Beaſts cannot ſuſtain hunger ſo long as birds, which are capable of living a great while without food; reptiles longeſt of all, for being by nature fitted for total inactivity, and ſleep, during winter, the ſame cauſes of torpor ſeem to act frequently at other times. The ſame idea applies to the ſpider and other inſects of prey.

We may place creatures which feed on fiſh, very naturally after thoſe which feed on fleſh: to this claſs we refer fiſh themſelves in general, ſome beaſts, alſo a great variety and proportion of birds; ſome of which ſeem as much natives of the ocean as fiſh can be; they ſwim, they dive, with incredible alacrity, and purſue their prey in the waters with equal eaſe and rapidity as you may have ſeen ſwallows chaſe inſects in a ſummer's evening; they even diſregard ſtorms and tempeſts, riſing and falling with the agitated waves, without alarm or diſcompoſure; could they form their neſts and breed on the water (ſuch a fable was current in antiquity), they would rarely viſit the ſhore. Theſe find a maintenance among their fellow aquatics. Since they devour life, thoſe birds and beaſts who live on inſects, may be conſidered as in cloſe union to the foregoing tribes, and only guilty of leſs apparent, but equally real ſlaughter.

There are not very many beaſts which live entirely upon fruit (the principal are thoſe of the monkey tribes), becauſe they are by form ill adapted to climb: the prize might tempt them, but is beyond their reach: whereas, birds being capable of ready motion from place to place, forage at diſ-

cretion; and, as our gardeners well know, without regarding whom they rob. There is ſcarce any kind of fruit but has ſome bird its peculiar devourer; either when budding, or while green, or when ripe, and often, different birds to its different ſtates. Even that poiſonous tree, whoſe ſhade is injurious, under which, if any one ſeek ſhelter from rain, the falling drops from its leaves will bliſter his fleſh, whoſe apples, fair indeed and ſightly, are yet mortal, and whoſe gum is poiſon (the manchineel tree); even this tree ſometimes affords food to parrots and mackaws; but it tranſfuſes ſo much of its qualities into their fleſh as to render them unwholeſome.

Creatures who live on grain, are uſually attendant on man; for as man multiplies and augments for his own ſake this kind of food, his labours contribute to the ſuſtenance of many, whether intruders on his proviſions, or fed by his protection. We have a remarkable fact in proof of this, in the paſſage of many birds into North America (from the iſlands and elſewhere) ſince thoſe parts have been cultivated. The Indians ſow little; the European ſettlers ſow much; and ſince ſo many thouſand acres have been ſubjected to the plough, they are annually viſited by (parrots, &c.) birds of paſſage, and have alſo reſidents formerly unknown. How theſe birds of paſſage acquired the knowledge that, at ſo many hundred miles diſtance were fields of rice and corn, muſt be referred to a principle of inſtinct, to be conſidered hereafter.

A diſpoſition to live on grain or herbage may be thought a principal characteriſtic of an animal capable of domeſticity; it ſeems to imply ſomewhat of a gentleneſs of nature, which indul-

ges not envious paſſions; whoſe wants are limited to ſimple fare, and ſecurity, and whoſe enmity toward other ſpecies is moderate, if not ſilent. This we ſee in the ox, the horſe, and is equally evident in the elephant, large as is his bulk. Does the peculiarity of food contribute to render ſome ſavage, and others mild? This is at leaſt one manner in which their ſavageneſs or their mildneſs appears; moreover, when we have in any degree brought certain creatures off from total maintenance by blood, we have ſo far advanced them toward ſomewhat of tameneſs; we have in ſome degree diminiſhed their ferocity.

Recollect, that the ſupport of life is left to the individual; In the inſtance of procuring food, we ſee this ſupport endeavoured according to the natures of the ſeveral creatures; that this diverſity has beneficial effect, ſeems proved, by reaſoning already adduced, and, as above hinted, it forms diſtinguiſhing marks of the claſſes of animals; but, like every other mode of claſſification, is liable to inconveniencies in treating creatures which combine ſeveral properties. Some eat fleſh and fiſh; ſome fleſh and fruits; or fruits and inſects; or inſects and grain; and ſome eat whatever preſents itſelf. There are few creatures but have predilection for ſome particular kind of food, even if the inſenſibility of their taſte ſeem ſatisfied with the firſt they can find. But if it be aſked, in what rank we muſt place man? It is clear he muſt rank among the omnivorous, from a direct contrary cauſe, not the inſenſibility, but the (ſuppoſed) ſenſibility and delicacy of his taſte (rather in many caſes its caprice). We eat fleſh, fiſh, in ſome countries

tries insects, as locusts, &c. fruit, grain, and what not? (lately you know we were amused with a stone-eater.) The flesh of beasts of prey is reckoned good eating, as lion's flesh and tiger's, but that of birds of prey coarse and worthless. The flesh of some kind of serpents is good; that of vipers, &c. is prescribed as restorative; and that of lizards lately is asserted to be a complete cure for the leprosy, and for the cancer.

We suggested another idea, without enlarging on it as it deserves; I mean position: but as the variety of this Discourse has been considerable, I would not wish to engage your attention any farther at this time of the evening; we postpone, therefore, that principle, especially as it has some relation to apparent intellect, which, together with some other particulars may form the subjects of another discourse, previous to our remarks on the senses, which I propose to treat separately.

LECTURE

LECTURE VI.

LADIES and GENTLEMEN,

THE first object of the present discourse is, to notice the differences of POSITION, and their effects on the manners of creatures. This principle evidently depends on the structure and conformation of the bones; and may require a few words on a previous question, which indeed divides into two propositions. 1. Whether the position of creatures, and their parts, is adapted to their way of life? Or, 2. Whether their way of life is the result of, and adapted to, their position?

Without the smallest intent of depreciating, or questioning the observations, and accounts of Mr. RAY, Dr. DERHAM, &c. (who seem to me to have taken affirmatively the first question) it is clearly inferable, that if creatures cannot do otherwise than they do, much of that *mental sagacity* which has been imputed to them, has been misapplied; and I am rather desirous to consider *sagacity* as a quality appertaining to reason, and connected with choice, than belonging to simple instinct. Admitting every moral consequence, admiring equally with those

thoſe gentlemen, the infinitely varied appointments of nature, yet I incline to trace them to other cauſes, and, reſtraining (much more at leaſt than they ſeem to me to have done) the operations of choice and volition, of intellectual faculties, and judgment, to mental and rational principles, I ſhall hint at a few particulars which may contribute to ſupport and juſtify my ideas.

Poſition may be conſidered as ERECT, or PRONE. In the firſt claſs, we place the human ſpecies, and birds; between theſe, and the intirely prone (as quadrupeds) I would rank the PSEUDO ERECT, or thoſe which occaſionally uſe both attitudes, as monkeys.

It has indeed been ſaid (ſomewhat jocoſely ſurely) that man is by nature *prone*; yet if the aſſertors of this doctrine would recollect the heavy head of man, his ſhort neck, his unprojecting mouth, his weak elbows, his ill made back, his worſe than uſeleſs hind leg, and his utter impotence of treading on his feet, in ſuch poſition, they muſt either relinquiſh the idea, or admit they had diſcovered a creature incapable of gathering his food (as other quadrupeds) on the ſurface of the earth, with a perpetual preponderance of his head toward the ground, without a power of eſcaping danger by ſpeed, but a mere crawler; and alſo, that nature had placed his feet, ſo as he could make no uſe of them. Diſmiſſing this crude idea, let us ſomewhat examine the manners of our fellow uprights (birds).

Among the moſt upright of birds, is the northern *diver*; who, when he ſtands upon his feet, is nearly, if not quite, perpendicular;

pendicular: for his legs are placed ſo far behind the centre of his body that, to maintain his balance, he muſt uſe this poſition. It is an evident conſequence, that his pace is rather a waddle than a walk; that if he project his head too far forward, he muſt tumble: this underſtood, how is this bird to get his living on land? His wings are not formed for chaſing prey by flight; he cannot pick up from the earth, grubs, inſects, or grain; he is web-footed, and cannot claſp the branch of a tree to ſettle on it; and how ſhall he ſecure himſelf from his enemies? a conſideration never to be forgotten. By theſe defects of conformation (for ſuch ſurely they are in a land-bird) the bird is of neceſſity urged to try his fortune on the waters; here he procures food by diving; an outſtretched neck here is no harm, but a benefit, by throwing forward his centre of gravity; from being *bolt upright* on land, he is *bolt downright* in water, ſo that few fiſh can eſcape him; and his web-feet are now his beſt friends. By the bye, this bird dives ſo ſwiftly, that he often eſcapes the ſhot by diving the moment he ſees the flaſh. A bird always in water, moving only on that element with freedom, and there only finding ſupport, would breed on the water if he could; but this nature has forbid: neceſſity determines to the ſhore, in this caſe, as to the other element, in other circumſtances.

The *Flamingo* has legs ſo long, that he hardly, if at all, dare ſit on the ground, ſo great is the trouble of riſing; how then ſhall the female ſit on her eggs? She raiſes a kind of mound of earth, &c. and, if I may uſe the expreſſion, *ſits ſtanding*: but this ſhe cannot do ſo as to cover the eggs with her

body; therefore, by the kindneſs of Nature, her hinder parts ſuffice.

As I think bills of birds clear inſtances that manners of life are determined by conformation of parts, I ſhall offer a few remarks on them here, though perhaps a little miſplaced; the bill of the *Flamingo* is ſtrongly arched *downward*; by this form it can neither *peck* as a cock, *ſeize* as an eagle, *grope* as a duck, *ſuck* as a ſnipe, or *pierce* as a wood-pecker: it muſt *bite*, in a particular manner, what grows above the ſurface of the ground. On the contrary, the bill of the *Avocetta* is ſtrongly arched *upward*; this then can neither bite, nor grope, nor pierce, nor peck, but it may ſuck: and not only it may, but it muſt. This bird, therefore, muſt be converſant in moiſt places, where its powers of penetration and ſuction may be efficient to procure food. The croſs-bill muſt bite on one ſide, the ſciſſor-bill muſt bite downward; the form of the part determines its motion; and, I think, determines alſo the creature to thoſe productions which it can attack to moſt advantage, and to that ſpot where thoſe productions are moſt abundant.

Very remarkable inſtances of poſition occur in the monkey tribes; ſome of them can ſtand upright; in this attitude they reſemble man, and by this poſitional reſemblance, without one ſuperior or additional idea above many creatures, which are properly prone (a dog has more ſenſe than monkeys in common), they perform actions which ſurpriſe us; becauſe we know, that we ourſelves perform thoſe actions in conſequence of previous conſideration, but they from ſimple inſtinct. A dog carries a burden in his mouth, a monkey

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uſes his hand (in this reſembling ourſelves). A dog cannot *catch* with his tail; but certain tribes of monkeys can (not in this alſo reſembling ourſelves). So tell a man to ſtretch out his noſe a yard or two—you ſmile: but an elephant has this power. —This is the conductor of his daily food.

There are ſeveral kinds of neceſſity: I have been ſpeaking only of that which ariſes from the members diſtributed to animals, which, I think, direct them to their ſeveral ways of life. Infinite ſkill has reſtricted the number and power of theſe, when given to individuals, or to particular ſpecies; but has varied the numbers and powers of them amazingly, by an amazing number of ſpecies, each differing ſomewhat from all others, even from thoſe which ſeem its neareſt neighbours. Evidently creatures are varied in powers and manners, as clay in the hands of a potter.

If the forms of creatures are thus fixed and appointed, are not their diſpoſitions the reſult of ſuch appointments? which otherwiſe were nugatory, or employed in vain: ſo that a propenſity to live on water, or land, to leap, to fly, is impreſſed upon theſe ſubjects correſpondent to their forms. Poſſeſſing, by nature, ſuch or ſuch faculties, are they not *prompted* to uſe them, in purſuing thoſe purpoſes for which they were given?—*i. e.* maintenance and ſupport, firſt of themſelves individually, then of their ſpecies. This ſeems to lead to a juſt idea of INSTINCT: which I conſider, as a determinate impreſſion communicated, by the great Author of all, to the original parent of each ſpecies, and tranſmitted to poſterity; an impreſſion, acting in a uniform manner, on uniform

form principles, on uniform objects, and reſtricted to wants and enjoyments which are always animal, and always alike.

How far inſtinct *may* be imparted to ſubjects of the vegetable kingdom, we know not; that ſome of its lower degrees *may*, is not *impoſſible*, but if they are, they are too obſcure to affect us; that ſome of its ſuperior degrees are connected (in ourſelves) to reaſon, is certain; that we, ſo far as animal, are ſubjected to many laws in common with other animals, is undeniable; as eaſily might be denied that our fleſh and blood reſemble thoſe of our fellow-creatures, as that we have many inſtinctive diſpoſitions in common with them. But, as in vegetables, inſtinct is obſcured by mixture with what is below it; in man it is obſcured by union to principles above it. We muſt therefore ſeek it as moſt active, and leſs encumbered by foreign circumſtances, among creatures of the middle rank of life.

Animal wants are principally food and habitation, for ſelf-maintenance (all other neceſſaries of life we have proved are provided); ſo far the individual is concerned, and theſe ſupplied is contented. But Nature ſubjects him to another duty; elſe when the individual were extinct, the ſpecies would periſh.

From the firſt of theſe principles reſult the various arts of creatures to obtain food, which we have formerly noticed: and now ſhall only introduce a few words on ſome particulars relating to their dwellings. Quadrupeds, in common, enlarge ſome hole to a convenient ſize for a den, where they may be concealed from obſervation; and with this they would generally be contented, had they no expectation of a family.

Birds,

Birds, I apprehend, though they might chooſe different places, yet would deſire nothing further; but each would endeavour, that its dwelling might be at as little diſtance as poſſible from the ſpot where it was accuſtomed to find nouriſhment. Thus, an otter would live on banks by the water-ſide, ſo would a beaver; that the firſt might with leaſt poſſible trouble procure fiſh, the latter the barks of trees attendant on water. Thus, the mole, who feeds on worms, neſtles in the earth where worms abound; thus, aquatic birds inhabit rocks by the ocean ſide, and others in other places where they have found, or do find, prey. Their courſe of principles ſeems to be, *firſt* food—this is always neceſſary; *ſecondly* dwellings—theſe are often neceſſary; *thirdly*, a combination of theſe two, *i. e.* plenty of food, and convenience of habitation, as occaſionally neceſſary: that is, when they are about to breed. This latter article ſeems to be determinately directed by nature. For inſtance, with regard to time: Nature fixes the deſire of poſterity to ſuch a time as will anſwer the period of geſtation; that when the young family is produced, proper food may be abundant. Is it enquired, whether the animal does not foreſee, and calculate, that moſt advantageous time? We anſwer, No: The events or ſituation of things at the diſtance of three or ſix months have no place in animal ideas; both the deſire and the power is reſtricted to a few days in each year, and muſt *then* be uſed or relinquiſhed. This is the caſe with moſt wild animals; thoſe which, under the protection of man, find always plenty of food, are degenerated from the natural laws of their ſpecies when they breed at other ſeaſons.

Inſtinct

Inſtinct is moſt notorious and evident, in what concerns the parent with regard to poſterity; whatever of contrivance is remarkable in dens, or neſts, may fairly be attributed to this; whether it regard warmth and ſoftneſs, theſe are for the young; or means of ſafety and eſcape, theſe are alſo for the young. Birds ſhew theſe principles very ſtrikingly in the conſtruction of their neſts. Some place them ſo as to enjoy the ſun: Is not this reaſon? ſay ſome: No, many plants, not ſuſpected of reaſon, incline ever to the ſun (as corn I think always does); other birds turn them from particular winds (as certain plants cloſe their leaves); ſome enter their neſts at bottom, their form forbids their convenient deſcent; others at top, they cannot aſcend: there is a determinate ſomething, which prompts to the uſe of clay, of down, of wool, of hair, of the roes of fiſh, in conſtructing their neſts, though to us at preſent unknown. Proviſion for ſafety and eſcape ariſes from parental feelings: birds who hang their neſts on leaves of trees to avoid monkeys and ſerpents; thoſe who conceal them with leaves ſo nicely as to be undiſcoverable; thoſe who breed in inacceſſible places, are inſtances of this. If thought and foreſight *may* be attributed to any, we might inſtance inſects, which, when they have laid their eggs in a fit cavity, incloſe four or five large maggots as a proviſion of food againſt the birth of the young, at a conſiderable interval of time.

[The ſame inſtinctive principle actuates the human ſpecies: Do we love our offſpring by reaſon, or a law of nature diſtinct from it? (*i. e.* inſtinct.) Even when, by their behaviour, reaſon is offended and ſhocked, ſtill a powerful affection is operative

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to ſoften their offences, and to alleviate their ſufferings: and prevails *againſt* the reaſon as well of parents, as of unbiaſſed judges.]

The poſterity of all creatures inherit the forms of their parents; and with their forms their manners; when the offſpring of an eagle ſhall be a ſparrow, we may expect it to ceaſe the chace, and live in towns; when the cub of a lion ſhall be a lamb, we may expect it to graze and be content with herbage: but while theſe creatures eſſentially differ, ſo will their manners; and (in the hands of Nature) without degeneracy, either in degree, or by alliance. This is a ſtanding law of Nature; and though ſometimes ſeemingly ſuſpended in mixtures of the leſſer branches of varieties of ſpecies, yet never is tranſgreſſed by ſpecies with other ſpecies; among varieties is always capable of remounting to the original parental ſubject; and, in fact, is abſolutely determinative of branches to their ſpecies.

The diſpoſitions of creatures then are in cloſe union to their forms, and equally tranſmitted: that Power which circulated the planets, impreſſed theſe diſpoſitions, rendered them laws, not leſs ſtable than the principles of planetary motion, of gravity and attraction, which ſhall not ceaſe till that power commands ceſſation.

Incapable of variation, theſe manners and procedures, determinately attached to the ſeveral ranks of creatures, are not taught by education. Thouſands of creatures know not their parents, who (in the inſect tribes) often poſſeſſed a different kind of life, having been changed, as their offſpring will be; yet will the young imitate the parent. The firſt of the

kind did the ſame, in the ſame manner; the laſt will do the ſame, without improvement; there have never been, never will be, degrees (implying progreſſion) of dexterity or knowledge; all ever have done ſo; ſo, and no otherwiſe: all ever will continue the ſame practice—but we ſee this practice ſometimes intermitted by accidental cauſes. A ſociety of beavers in ſecurity build dams and dwellings; this implies united efforts; but where man ſpreads habitations, this ceaſes. *i. e.* the creatures become inſecure, are occupied with individual ſafety, are alſo diſperſed; and in this ſtate no beaver builds any thing like a dam, but inhabits a hole. The ſame is ſaid of bees, and of other gregarious creatures when ſolitary.

Inſtinct, though incapable of improvement as relating to the ſpecies, yet is capable of injury; ſuch is the power of man! A parcel of rabbits bred in domeſticity, will not readily learn to burrow; but often the whole periſh, through ignorance of what belongs to their kind. Domeſtic fowl, if turned out to become wild, do not for a long time make neſts, like thoſe native of the woods. The reaſon is, their wants have been ſupplied without their interference; they become therefore ignorant of the preſſure of ſuch wants, and do not get into the track of their ſpecies till after a time.

Though inſtinct is incapable of elevation as regarding the ſpecies, yet under the direction of reaſon it ſeems to acquire ſomewhat of which before it was deſtitute: this is beſt ſeen in a dog (which, as I hinted, has much ſuperior parts to a monkey, whoſe ſeeming cunning is mere imitative action).

It must be owned that man has found the art of imparting his orders to, and insisting on obedience from, sundry animals: a dog may be taught to fetch and carry, even to steal and plunder, to watch goods, and so on: these are natural actions, which the creature might often do for himself in a state of nature; the peculiarity is, his doing them for his master. This is the effect of instruction, inforced at first by fear (*i. e.* of chastisement for omission), or hope (*i. e.* of food as reward for performance); but this art has no effect beyond the individual. Is the posterity of a drum-beating hare more courageous? of a dancing bear more graceful?—Moreover, these instances are always considered as outcasts, and destroyed by those of their species which have perserved their liberty. Tamed hawks are pursued by wild ones; and birds escaped from cages, I believe, are commonly killed by others. A parrot may speak; but does that enlarge his stock of ideas, or render them more *mental?* A lion may be tamed; but he is no longer a lion: and elephants may be taught to stand fire; but surely they lose so much of their elephantine character. All that results from these instances is, that man has power to *uncharacterise* certain creatures, whose docility is suitable, and whose disposition he has studied; while certain others defy his utmost endeavours, and maintain the liberty of savage nature in themselves, as well as their species.

Upon the whole, I infer, that the talents of creatures are influenced by their forms; that in their manners is no choice, no variation, no consideration of the labours of their fellows, no improvements adopted from other species; that we might as well praise a tree for the properties of its leaves, for the beauty

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of its bloſſoms, as animals for ſuch exertions. In referring to theſe principles, ſurely I do not leſſen *admiration*; I admire, as inſtances and appointments of divine wiſdom, the beauty of bloſſoms, and the properties of plants; the manners of animals, their arts and contrivances; their very uniformity alſo is worthy of admiration, and proves the care of their divine author as continued to the works of his hands. Nevertheleſs, when compared, inſtinct differs greatly from every degree of reaſon.

In comparing inſtinct to reaſon, I would obſerve, that (1) Inſtinct differs in different ſpecies, but not in individuals of the ſame ſpecies; whereas reaſon is undeſcribably various: how often do two perſons from the ſame reaſonings, the ſame circumſtances, the ſame *poſtulata*, draw totally diſſimilar inferences! (2) Inſtinct deſcends from parent to offspring with undiminiſhed powers: this is evidently not always the caſe with reaſon. (3) Inſtinct is little varied in the ſame ſpecies throughout the world: but what ſhall we ſay to the contradictory cuſtoms, manners, laws, &c. of mankind, each of which is aſſerted as a dictate of reaſon? (4) Inſtinct has concerns and enjoyments only related to animal nature: when hunger is ſatisfied, repoſe, or paſtime, fills up the interval till hunger repeats its importunity. But this is not the caſe with reaſon; who is perpetually inquiring after *new* objects, prying here, queſtioning there, ſuppoſing, gueſſing, inquiring, is it? is it not? ever reſtleſs and diſſatisfied with preſent attainments. This principle alone were ſufficient diſtinction: the content of inſtinct, the diſcontent of reaſon. (5) If inſtinct may ſometimes trace

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cauſes to effects, as ſome ſay ; I conceive it never traces effects to cauſes, as reaſon does. It never cultivates the earth for food, nor lights a fire (nor keeps one in, when by accident it has got one), though theſe are *animal* enjoyments. Reaſon ſeems unlimited ; it ſoars into other realms of ſpace ; it invents variety of arts, of ſciences, of implements, to accompliſh purpoſes foreign to every conception of inſtinct.

I know not how far I may conſider a conſcious ſenſe of right and wrong, of juſtice and injuſtice (*i. e.* moral rectitude), as diſcriminative of reaſon ; or, a ſenſe of our dependance on a ſupreme being, our author and benefactor (*i. e.* piety) ; or, a concern for the good of the whole ſpecies (*i.e.* benevolence) ; or, of the community to which we belong (*i. e.* public ſpirit) ; or, *permanent* ſympathy and affection to the various branches of kindred, or friendſhip, as peculiar tokens of reaſon ; but this I think clear, that genuine reaſon would feel the full force of theſe ſentiments, and thoſe totally ignorant of them are fit to be ranked with brutes.

Reaſon has for its object, the improvement of the mind, an elevation of mental principles, a perfecting of mental talents ; mental ornaments are its badge, mental enjoyments its pleaſures ; it aſpires after infinity itſelf, and can ſcarce be perſuaded to contract its deſires according to its capacity. Far from being contented with animal life, it emulates ſpiritual and ſupernatural powers. The very calls of nature have been in thouſand inſtances ſuſpended by meditation ("I forgot I had dined," ſaid Sir Iſaac Newton ; but he had not dined, his friend having cleared the cover). Vigorous imagination and lively

fancy

fancy have been greater ſources of delight to many, than all poſſible pleaſures attendant on the ſenſes.

What then is REASON? The reſult of intellectual faculties, or mind. What is mind? I know not: I perceive its effects, I am conſcious of its exiſtence, but rather infer, than underſtand, its nature. I think it, a certain principle *ſuperadded* to what we call life, capable of choice and determination, of right and wrong, of good and evil, of which animals are incapable.

As the corruption of the beſt things is exceeding bad, ſo by depravity of his reaſon, man has wandered from his direct path of duty into a maze of error, till his real nature is forgotten; till wiſdom and folly almoſt reſemble each other, in that point of view from whence he ſurveys them; and his deportment preſents a confuſed aſſemblage of excellent and worthleſs, of great and ſmall, of magnificent and deſpicable, of amiable and abſurd. Notwithſtanding which, man maintains great ſuperiority over his fellow-creatures; but it is probable, the higheſt intellectual acquiſitions that have ever graced the human race, are but feeble reſemblances of what were his original appointments, as our higheſt degrees of rectitude equal not thoſe of our firſt formation. It is true, the whole nation of man, by the exerciſe of remaining reaſon, is greatly removed above the brutes; but what was the *original* diſtance!

The article VOICE is, I think, not to be forgotten, in recollecting our ſuperior qualities: I confeſs animals have expreſſive ſounds; but this is not all which is comprehended in the idea of voice. The ſounds of animals expreſs corporeal feelings, but have no relation to mental ideas; pain, pleaſure, of

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the body, wants of the body, no idea of reaſoning, no communication of ſentiment, no mental exchange; therefore few ſounds, and ſimple; few vocal inflections, but determinate, and always ſimilar. According to the ſtructure of the parts, a roar, a cry, a ſcreech, a croak, a whiſtle, uniformly repeated. Their ſounds may be referred to, (1.) fear; (2.) diſcovery of food; (3.) courtſhip; (4.) pain; and in the young, a voice exciting attention. Theſe are appropriate to each ſpecies; no two ſpecies affixing the ſame ideas to the ſame ſounds.

Beaſts cannot be (that I know of) taught to imitate human language: but as if birds were to reſemble us in other articles beſide attitude, many birds acquire it; canary birds, often, ſparrows, linnets, and perhaps moſt ſong birds, whoſe organs being more flexible, are capable of greater adaptation, who have natural inclination to voice of ſome kind, and who being very early accuſtomed to the pronunciation of theſe words or phraſes, receive them as ſubſtitutes for the genuine ſong of their ſpecies; which many of theſe ſpeaking birds never heard.

Parrots, however, are the notorious inſtances of ſpeech, which ſome acquire very perfectly; together with the imitation of laughing, crying, counterfeiting ſickneſs, and other oddities. In fact, the peculiar formation of a parrot's bill and tongue, has ſome likeneſs to the human, and qualifies it for modulating ſound. The generality of animals form the ſounds they emit, not in the mouth or throat, but in the belly: parrots themſelves are ventriloquiſts; the ſound is formed *deep*, but is inflected by the tongue and bill.

The bill of a parrot is round without, hollow within, containing a pretty large cavity, admitting free motion of the tongue, and reflecting the ſound from the circulat extremity of the lower mandible (as from a row of teeth in that part) to the upper mandible, which has the effect of a palate, ſo that the ſound is not ſpent in a mere whiſtle, but acquires a fulneſs of tone, which the tongue determines to certain articulation: the tongue is round and thick, larger in proportion than the human. Beſide theſe particulars, the upper mandible of the parrot's bill has a peculiar mechaniſm, whereby it is capable of motion, and which probably contributes to the direction of ſounds to reſemblance of the human. Among the various languages of man, ſome are ſooner learnt by birds than others, as better ſuiting their organs; the voice of children alſo is more adapted to them than that of grown perſons.

The important advantages of voice are ſo obvious, that I ſcarce need repeat them: thoſe creatures which are without this quality have (I ſhould think) fewer ſenſations to communicate than others. Fiſh neglect their offspring; a *call*, therefore, would be uſeleſs: they have no need of means to ſignify parental affection, ſince they poſſeſs not the principle; and if this principle be (as I conceive) the ſtrongeſt in nature, we may conclude creatures deſtitute of this have little other to expreſs. Voice ſeems to be given to beaſts of prey, to impreſs terror on the objects of their purſuit; it is in this ſenſe a kind of weapon, not unlike the Indian war-whoop, which, to unaccuſtomed ears, is dreadful and intimidating. The roar of a lion diſturbs all creatures within hearing, let them be never ſo

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ſecure from his approach. Birds of prey, I believe, ſeldom uſe their voice while in chaſe, purſuing by ſight, and truſting to rapidity, not to ſcent or hearing. Voice alſo excites pity, as appears in the ſloth, whoſe moan is ſo plaintive, that ſcarce any creature will moleſt it. As to the effects of the human voice in exciting ſenſation, or the melody of its muſical ſounds, I need ſay nothing: none are inſenſible to the accents, any more than to the expreſſions, of friendſhip; none can miſtake the tones of anger for thoſe of entreaty, or complacence. The difference of voice is a remarkable appointment of providence, and often ſuffices to identify perſons with whom we have been converſant. It is wonderful that theſe differences ſhould be ſo extenſive and determinate, yet proceed from parts of a ſimilar conſtruction, or very minute variation.

STRENGTH muſt depend on the conſtruction of bones, and the powers and application of muſcles to move thoſe bones. Muſcles are provided with ſtrength more than merely ſufficient for that purpoſe; otherwiſe, were any one, or part of one, out of order, the creature would have no reſource. The largeſt creatures having the weightieſt bones, their muſcles will have the greateſt *ſurplus* of ſtrength. Birds have not equal ſtrength with beaſts: their bones are not ſo heavy; even in their flight, art divides the honour with ſtrength. The principal ſtrength of creatures reſides in various places; hence their different modes of defence: that of man ſeems ſtationed in his legs, in order to enable them to ſupport the fatigue of walking. We have many inſtances of ſtrong men, but ſeldom in civilized life: men of great ſtrength, great ſize,

great ſpeed, great voracity, or any other merely animal quality, are uſually among the leſs cultivated part of the ſpecies. It is likely that man originally excelled in animal qualities as in mental; that in rapidity no creature could ſurpaſs him, nor in activity and adroitneſs, nor in ſtrength combined with its application, for we ſee remains of moſt of theſe in ſome or other of his poſterity; their union would demonſtrate his pre-eminence in theſe (though inferior) reſpects. As it is, he contrives to render theſe qualities in creatures ſubſervient to his purpoſes; and thus obtains his ends, with little fatigue to himſelf, and with the advantage of being able to direct many, while otherwiſe he could engage but one (himſelf).

The courſe of a day is a hiſtory of life: from the darkneſs of non-exiſtence, ſymptoms of light and being gradually open upon us; the dawn clears and brightens, becomes more luminous and ſplendid; then it fades, and day appears, cool and ſerene, the mother of expectation and activity! The meridian of life is ſultry, and ardent; its decline, to thoſe who reflect on well-ſpent hours, cheerful and eaſy: ſuch may welcome the calm of evening with complacence, and with tranquillity expect the period of repoſe, when, diveſted of mortal clothing, what is immortal ſhall quit its terreſtrial garment. The gentle image of ſleep, as expreſſing death, has ever been favourite among mankind: it is a ſort of daily death, yet indiſpenſable to the maintenance of life: it is a ſtate of repoſe, and recruit, to all creatures, which none is at liberty to omit; though they chooſe different ſeaſons for its enjoyment.

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A perpetual efflux of ſpirits, without recruit, muſt needs be waſting, and of fatal tendency; or, if the recruit be unequal to the conſumption, progreſſive weakneſs muſt be the conſequence. The effect of labour is perſpiration; that of perſpiration is ſuch a conſumption of ſpirits, ſo that in an evening moſt perſons are ſhorter than they were in the morning (often by half an inch, or a whole inch); and many a ſoldier, who when enliſted has meaſured the neceſſary height, has been found much under it after travelling ſeveral days to join his regiment. It ſeems probable, that this effect ſhould be greateſt in hot climates: may not this daily fluctuation of parts contribute to the brevity of life among the negroes?

The waking waſte of ſpirits is reſtored *in* ſleep: whether it be alſo reſtored *by* ſleep, or whether ſleep be only a ſtate neceſſary to that effect, may be debated. Whether by its excluſion of ſenſible ideas, it forbids diſſipation of the finer ſpirits, while it promotes a more general and intimate penetration of thoſe fluids neceſſary to ſtrength throughout the body, or whether it may affect, and in any ſenſe nouriſh, the head only, or principally, is a difficulty. The nouriſhment ariſing from ſleep is often interrupted by imperfect ſleep, or diſagreeable dreams; and is counteracted by too much ſleep.

With regard to dreams, they ſeem to be a fortuitous concourſe of ideas formerly received by the ſenſes, more or leſs regularly arranged, more or leſs diſtinctly remembered: in common, they are ſufficiently incoherent to prove they are not the offſpring of reaſon; and, ſo far as I can judge, have always ſomething of contradiction, or deficiency, or imperfection in them,

which

which is very ſenſible. They reſemble the actions of a parcel of ſchool-boys, whoſe tutor has quitted them for a time, but whoſe return is quickly expected; they ſeem to be aware that their regulator (reaſon) is neither among them, nor on their part. But it muſt be owned, that many perſons have dreamed ſo circumſtantially and minutely, ſo forcibly and impreſſively, that they have ſcarce known how (if at all) to diſtinguiſh between fancy and fact, or to determine whether theſe ideal, have not been actual, events of their lives.

Dreams by day, and dreams by night, attend the progreſs of life: events which are paſſed, are but like the faint traces of imaginary impreſſions. Memory is indeed a wonderful faculty; but often overwhelmed by multiplicity of avocation: how many thouſand forgotten ideas have paſſed our minds! The preſent is our only actual life, memory is a reflective life. Let us ſee if it will trace our vital progreſs; let us ſee if we know the portrait, when the picture is held up to our view.

Whatever may be the powers of man, no tokens of ſuperiority appear at his entrance on this ſtage of things: though his animal part be united to a wonderfully ſuperior principle, yet they now offer only a ſpectacle of moſt helpleſs union; complete imbecility deſcribes the new-born maſter of creation. It is true, he opens his eyes (which few animals do), but they rather gaze than ſee; light impreſſes them, but the impreſſion is idle. To the faculty muſt be added, uſe, experience, a thouſand inſtances of its detected fallacy, and a habit of correcting its miſtakes, by repeated compariſons and examination, ere it deſerve the name of ſight. The ſame is the

ſtate

ſtate of the other ſenſes; the deceptions of hearing and feeling, could we relate them, would probably be very extraordinary. Laughing and crying are early attendants in life, and they keep cloſe to our company throughout.

As to form, the head of childhood is large; as the ſenſes require room even for their immature exertions. The diſtinguiſhing character of youth is ſoftneſs of fleſh, and redundance of fluids. As our ſolids are compoſed of what has been fluid, plenty of moiſture is aſſigned to that ſtate which, beſide providing for preſent ſupport, is gradually increaſing in ſtrength and dimenſions. The growth of children is ſwift at firſt, and gradually diminiſhes as life advances: it was neceſſary that *ſo much* ſhould be done, to permit the functions of life, and the exerciſe of reaſon; but maturity arrives by ſlow degrees, and yearly, as it advances, its ſpeed leſſens. The mind acting, and diſcerning, only by means of the body, follows the ſame rule; is at firſt rapid in general acquiſitions, then ſettles into a more even tenor.

It is very amuſing to purſue the young mind in its early attainments. At about a year old, the neceſſities that firſt engaged its faculties, increaſe, as its acquaintance with nature enlarges; and having experienced what gave pleaſure, it deſires repetition of that effect from that object; in order to which, it muſt be identified: hence ariſes a new neceſſity, and the child is at laſt obliged to ſet about naming what it deſires to poſſeſs or avoid. This begins uſually about a year old. After repeated trials they pronounce ſome letters, then others; but not without effort of memory can they retain them.

We frequently ſee them attempting a ſound which they had learned, but forgot. The letters ſooneſt learned, are thoſe moſt eaſily formed; A and B require an obvious diſpoſition of the organs, and their pronunciation is ſoon attained. Z and R are learned with greater difficulty. And this may be the reaſon why children in ſome countries ſpeak ſooner than in others; for the letters moſtly occurring in the language of one country, being ſuch as are of eaſy pronunciation, that language is of courſe more eaſily attained. The children of the Italians are ſaid to ſpeak ſooner than thoſe of the Germans; the language of the one being ſmooth and open; that of the other, crowded with conſonants, and extremely guttural.

Education has great influence, if not on acquiſition of ideas (*i. e.* learning), yet on that branch which ſhall be moſt intimately acquired. In the preſent ſtate of ſociety, the branches of learning are ſo various, no one mind can underſtand them all: ſtill more difficult is it to determine which of thoſe branches will beſt ſuit the genius and diſpoſition of any individual. But there are certain principles never to be omitted; ſuch as the control and guidance of the paſſions, habits of induſtrious attention, ſtrength of mind, as well as body, and good morals, whoſe aſpects on future life are of extreme importance; theſe *condenſed* into fixed habit, render many evils of life fugitive, many others eaſy, many others they deprive of evil, and ſome they turn to benefits; while all advantages of life they improve, and give a zeſt to all its enjoyments.

After

After the ſports of youth, and the acquiſitions previous to, and neceſſary for, maturity, that period arrives, at which no farther bodily progreſs is expected; nature has puſhed on to thoſe dimenſions which correſpond with the ſtandard appointed the ſpecies, ſpreads into life no further in the individual, but lays her commands, and diſpenſes life by his means.

Some perſons ceaſe growing at fourteen or fifteen; others at two or three and twenty. During this period all are of a ſlender make; their thighs and legs ſmall, and muſcular parts unfilled. By degrees, the muſcles augment, and the limbs become rounder. The female ſex arrives at perfection and maturity much ſooner, the muſcles being weaker, leſs compact and ſolid, require leſs time; and, being leſs in perſonal ſize, that ſize is ſooner attained. Hence they are as complete at twenty, as men at thirty.

That redundance of moiſture which is neceſſary to childhood is withdrawn at maturity; and firmneſs of body and mind characteriſe this period of life. We can eaſily conceive, that as the fluids loſe their fluidity, they become leſs fit for intimate penetration of the minuter orifices and pores; that theſe, if not penetrated, may cloſe, and thus the ſolids harden, their reſiſtance becomes greater, while the power of the fluids to enter them becomes leſs. The finer ſpirits are inferior in quality and quantity, conſequently tranſmit but impotent commands to the muſcles, which they *ſhould* actuate. The muſcles, leſs able to execute, become by degrees unapt in execution, and require united aid to overcome, what formerly were no obſtacles; thus a general rigidity ſupervening, debili-

tate[s]

tates the whole frame: this is the effect of age. It is a kind of prediſpoſition to return to earth, which has always had a ſhare in our compoſition, and which now predominates: not only thoſe cartilaginous ſubſtances which *tip* the bones become bony, the very oil which lubricated them becomes clammy, the muſcular veſſels which once acted on the blood (the arteries) harden; the blood itſelf thickens, and often concretes; the brain, the ſeat of ſenſation, dries; and the whole frame ſeems haſtening toward a period when it may crumble into duſt.

In how few words is compriſed the hiſtory of human life, and the principles of old age! Whatever be the variety of ſcenes which a perſon is called to paſs through, buſy or idle, ſedentary or laborious; whatever may have been his diſpoſition of mind or body; whatever his ſtation, his character, his conduct; whatever his fears or his hopes, whether willing or reluctant, this is the goal to which he is haſtening. No mental abilities can prevent the ſolids from hardening, the fluids from thickening; no care can avoid it. But though old age cannot be poſtponed, or avoided, it may be prematurely accelerated, at leaſt in its inconveniencies; ſince other cauſes may *dry* the ſprings of life; ſuch as violent paſſion, which extravagantly diſſipates the vital fluids, intemperance, which oppreſſes them, or other criminal indulgences, whoſe malignancy is notoriouſly detrimental to the vital powers.

The imbecility of age before its natural period of years, is perhaps the greateſt affliction of life; if irremediable deſpondency, united to inceſſant expectation, a hope of better times, perpetually

perpetually quaſhed by hourly diſappointment, and a ſenſe of how long time nature may languiſh under its burden, may render affliction great. But in mature old age, there is much that is cheerful, by ſympathy with others; and ſo gradual an acceſſion of inconveniencies, that habit has time to become familiar with them; there is alſo gradual retraction from the amuſements of life, gradual loſs of faculties, of friends, and gradual deſcent to the ſilence of the tomb.

As the flower, blooming once, but now decaying; as the ſhock of corn fully ripe; as the tree which has ſtood many ſeaſons, but yields at laſt to the fatal ſtroke; ſo falls the animal part of man. Death is a decompoſition of the principles of human nature; not an extinction, ſince one of them is beyond his powers. Indeed I do not know that poſitive extinction of any one principle in the world is in Death's power; he can only alter appearances, or vary their compoſition, returning it to its firſt principles, or concealing it by others. A vegetable, formed of the elements, enjoys and uſes them for a time, then returns them undiminiſhed: its air is again reſtored to the ſurrounding atmoſphere, and is free to become vegetable again, perhaps in the poſterity of its former owner: its earth is but returned to the common ſtock from whence it was borrowed, and may again ſhoot into the gaudy tulip, or ſupport in magnificent umbrage the majeſtic cedar. What has been animal, contributes to fertility; and, under the form of manure, in part compoſes herbaceous verdure, or the golden grain. The utmoſt power of Death reaches but to a ſuſpenſion of ſenſation; and this, perpetually renewed, defies

fies his perpetual efforts: Nature and Death have been long ſtruggling, but neither is victor, nor ſhall be, till, by apparent ſubmiſſion to his conqueſt, Nature ſhall riſe, endued with properties beyond his power. What then ſhall riſe? the tribes of animals? This cannot be: they may be re-created, but not raiſed; for to what *remaining* principle can they be *re-united*? The human frame itſelf, that "paragon of animals," is but a machine wound up for a time, and ſuffers like diſſolution with others; whereas that principle which we termed Mind, which we conſidered as ſuperadded to life, as capable of choice and determination, of good and evil, has properties independent of the *machinery* of our nature. We have ſeen, that no animal enjoyments can ſatisfy it, nor animal acquiſitions content it; that it graſps at objects far beyond the comprehenſion of animal nature; that it is ever learning, ever exerciſing its powers in new purſuits, ever diſcontented with preſent attainments, and capable of enjoying—what can it not enjoy? what that is ſublime, pure, noble, elevated, can it not enjoy? Is it credible, that a principle ſo capacious, ſhould receive a few drops of knowledge, and be inſtantly diſmiſſed; that a principle ſo deſirous of learning, ſo adapted to receive it, ſhould juſt commence its alphabet, and be conſigned to total ignorance; that intellectual pleaſures ſhould be ſcarcely taſted ere withdrawn; and the nobleſt of faculties, after aſcending a ſtep or two in ſcience, be rudely tumbled among non-entities? We pity the plant juſt ſpringing from the earth, we water and tend with ſolicitude the tender germ; we feel unſpeakable intereſt in the birth of a child; its firſt ſight, its firſt movements,

excite moſt lively affections in us: is it credible that our heavenly Parent, poſſeſſing every divine perfection, ſhould be adverſe to that part of his works which bears his image? That while he has implanted in *us* keen attention to a life, frail and expoſed, limited in powers and capacities, he ſhould himſelf be the deſtroyer of that which is capable of endleſs duration, of intelligence wherever are objects to be underſtood, and of delight in its higheſt degrees? The thought is unworthy rational acceptation. I am perſuaded it never riſes to a ſentiment, is never entirely and totally believed; but is a refuge of diſtracting guilt, a would-be ſuppoſition of polluted terror. Let me cheer you, my friends, by reminding you, that all the pains of life are not ſo much as momentary, compared to our entire exiſtence; that infinite pleaſures await us, to deſcribe which every metaphor derivable from what is pleaſant, has been adopted, yet all have fallen infinitely ſhort of juſt deſcription: all we know is, that the very utmoſt powers of the rational, the immortal mind, ſhall be repleted, let them diverge as they may; that the preſence of all *good*, the abſence of all *evil*, ſhall unite to perpetuate its felicity: is not this the felicity of DEITY itſelf?

LECTURE VII.

LADIES and GENTLEMEN,

WHATEVER may be the occurrences around us, or by whatever principles our animal frame may be actuated, the modes under which we receive information concerning them, are reduced to a few ſimple and regular operations, which we term SENSES; by theſe we feel, or ſee, or hear, or ſmell, or taſte; what knowledge we acquire, is by one or other of theſe mediums, and theſe are unqueſtionably ſufficient for the purpoſes of human life.

I have heard it ſuggeſted, that poſſibly animals have other ſenſes, whoſe office may be to direct them in choice of food, and other ſelections neceſſary to their comfortable ſubſiſtence, to guide that principle we call inſtinct, and to determine, by ſummary proceſs, between advantageous and detrimental. This idea ſeems to me erroneous, as ſuperior degrees of theſe very ſenſes are capable of accompliſhing every requiſite purpoſe; yet that there may be ſuperior orders of beings, whoſe more numerous, and more extenſive faculties, may by compariſon render ours but trivial, is beyond denial; but

theſe

Feeling.

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theſe we have little need to inveſtigate, till we have cultivated our own to that perfection of which they are capable.

That ſenſe which is moſt generally diffuſed, and which is alſo moſt exact, which is moſt ſpread in the individual, and moſt freely beſtowed to every rank of creatures, is FEELING. There are ſome which (ſeemingly) poſſeſs this only; but there are none poſſeſſing others, yet deſtitute of this.

How far ſubjects of the vegetable kingdom may poſſeſs ſenſes, we know not; we diſcern no proviſion made for their exerciſe; but if ſuch proviſion may be, it relates to the ſenſe of feeling. The advances toward the exerciſe of feeling which are exhibited by vegetables, appear in their flowers, ſome of which, if touched within their petals by a fine needle, at the time when their farina is ripe, will tranſmit the *impreſſion* to the ſtamina (on which the farina reſides), and cauſe them to ſhed it. By what mechaniſm this is performed, we know not; it ſeems to be the height of vegetable ſenſation, and contributes to ſtrengthen the idea, that whatever is related to life is the object of nature's eſpecial care, and higheſt contrivance.

Poets have, with their accuſtomed licenſe, uſed the phraſes "all eye, all ear:" the expreſſion "all feeling" is, I believe, coming nearer to fact. I doubt if all our ſenſes are not ſtrongly related to feeling, and whether they are not more delicate degrees of this quality, varied and diverſified, but not ſuſpended; much leſs entirely diſcarded.

The ideas we have ſuggeſted on this ſenſe include, (1.) Its liberal donation throughout all ranks of creatures. (2.) Its general

diſtribution in the individual. (3.) Its accuracy; and to theſe we muſt add, (4.) The mode of its action. A few words on each of theſe may agreeably occupy our preſent opportunity.

All ranks of creatures are endowed with the ſenſe of feeling, but not all alike, or in equal degrees. Fiſh I conceive to have the ſmalleſt ſhare, alſo cold-blooded animals in general. When we conſider the denſe and cold fluid in which fiſh reſide, its increaſing coldneſs and denſity at conſiderable depths, we may perhaps, with little riſk, regard theſe creatures as void of delicate feeling; ſince otherwiſe, the ſudden changes ſome of them are perpetually experiencing muſt be extremely injurious. I am not ignorant that ſome kinds of fiſh (whales, &c.) are of warm blood; but, beſide that theſe breathe like land animals, they have alſo prodigious defences of fat ſurrounding them, by its thickneſs *keeping in* their own bodily heat, and *keeping out* the cold of the circumjacent waters; they are not therefore *true* fiſh, but of equivocal character. The rapidity of fiſh is great; it is ſcarcely hyperbolical to ſuppoſe, that one (a ſhark for inſtance) may to-day be deep beneath the ice in the coldeſt of waters; to-morrow, or next day, may ſport on the ſuperficial waves of the Tropical ocean. Such ſudden changes would deſtroy a land animal, yet ſeems to affect fiſh with no inconvenience. Whales, porpoiſes, dolphins, &c. fiſh of warm blood, have ſuperior degrees of feeling; yet the fat of a whale is ſo inſenſible, that if a harpoon penetrate no deeper, the creature ſcarce winces; and not till the weapon penetrates the fleſh, does he ſhew ſigns of conſiderable ſenſation.

Cold

Cold blooded land animals agree with fiſh in having little ſenſe of injuries. We have hinted at ſome which regard the loſs of a limb as a trifle, and which, if the fracture happen at an inconvenient part, themſelves break off the remainder to a proper ſpot from which to reproduce the member. Of this number are certain kinds of lizards, and I believe not a few inſects.

Quadrupeds have this ſenſe in ſuperior degrees; yet if we may reaſon from appearances, the thickneſs of their hides, and their additional coat of hair, muſt not a little blunt its exerciſe. There are ſome which no blows can move; as there are others (I do not ſpeak it with pleaſure) which receive ſo many blows, one would hope they had leſs feeling than we have reaſon to allow them, or at leaſt, that beating would harden their ſkins to inſenſibility.

It is evident that ſuperior degrees of feeling may be expected, where the medium between the ſenſe and the object is thinneſt, and leaſt refractory, and the union cloſeſt. This ſuppoſes, that the means of ſenſation are of equal powers; but that ſome may be ſuperior to others in quality, as well as more numerouſly diſtributed, is no doubt; and perhaps occurs in every individual.

We proceed to notice the general diſtribution of this ſenſe throughout the individual. If we inſtance ourſelves, where ſhall we deny its preſence? From the head to the foot this ſenſe abounds; hence we become in every part ſuſceptible of pleaſure, of pain, of heat, of cold, of wet or dry, of whatever is rough or ſmooth, ſharp or blunt. The ſenſation affects us

every where, and every where alike; it is not here rough and there ſmooth, though ſome parts of us are leſs ſenſible of roughneſs and ſmoothneſs than others.

In general we ſay, feeling accompanies the ſkin; yet let us remember, that the outermoſt ſkin is void of feeling. We ſometimes ſcratch it without perceiving the wound, and we ſometimes raiſe it with a pen-knife, without injury. This becomes of great thickneſs by being uſed; hence the hands of ſailors, ruſtics, or others engaged in laborious occupations, loſe all delicacy of feeling; hence the ſoles of the feet in thoſe who walk much, are leſs tender than of thoſe who ride; and if we did not uſe ſhoes, the ſole of the foot would become inſenſible to the ſtones of the ſtreet, or the gravel of the road. The inner ſkin is the ſeat of feeling.

There are other parts of us which have little feeling, as the nails, the hair, bones, &c. Reaſoning by analogy, we may conceive of creatures as poſſeſſing this ſenſe very generally, yet having thoſe parts moſt liable to injury void of it; as the hoofs of quadrupeds, the ſhells of the cruſtaceous tribes, and generally all weapons of defence.

The accuracy of feeling is beyond the conception of thoſe who have not ſomewhat attended to it. The moſt obſervable ſeat of this is the palm of the hand; other parts may receive or communicate a leading, or groſs idea, may determine of heat and cold, &c.; but the hand not only judges of theſe with more exactneſs, but alſo of forms, of weight, of motion, with minute accuracy. In determining of forms, the hand not only diſtinguiſhes round or ſquare, a plane or a globe, but

their

their compound figures. This is evident in the delicacy of feeling acquired by various artists in handling their tools, where a perſon unuſed to the buſineſs ſhall perceive no difference, the artiſt himſelf ſhall find, one and another tool does not ſuit him. The hand too judges ſo accurately of what reſiſtance it meets with, and adds ſtrength more or leſs, as wanted. You muſt have obſerved this in writing or drawing, or fingering of muſical inſtruments; what ſurpriſing delicacy of touch ſome perſons poſſeſs! To what accuracy an excellent player on the violin adjuſts the preſſure of his finger on a ſtring! Not that he ſees where he places it, but by habit, his feeling accompliſhes his purpoſe. That linen and woollen, and cotton manufacture, ſhould feel different, is little wonder: but I remember to have read of a perſon who would diſtinguiſh blindfold between ſilks of the ſame nature from different manufactories, though their apparent texture was alike. On the ſame principle, perhaps, do ſome blind men feel colours. The late Mr. STANLEY, the organiſt, who was blind, would often lay his hand on the ſhoulder of a friend, and tell him the colour of his coat; or ſurpriſe one by ſaying, why do you wear ſcarlet? who are you in mourning for? or, what a lively brown you have on to-day! This can only be accounted for by ſuppoſing, that the dyes of theſe colours were compoſed of ingredients, which did not feel alike to a touch ſo delicate. Somewhat the ſame is reported of Profeſſor SAUNDERSON; and eſpecially that he once diſtinguiſhed between a ſeries of forged antique medals and the genuine ones, by the ſagacity of his touch, though all had paſſed for genuine on a celebrated antiquary. He could alſo

tell, when walking in a garden, whether he approached a tree, or other object, though there was no perceptible air to any other of the company. Nor is this all which the ſenſe of feeling has been known to do; for we have authentic accounts of an artiſt, who, though totally blind, could model perfect likeneſſes: he modelled the Grand Duke of Tuſcany, being purpoſely kept in the dark, and the likeneſs was extraordinary. It being objected, that the Duke's beard contributed a peculiarity to the likeneſs, he modelled one of the Ducheſs's maids of honour with equal ſucceſs. His portrait yet exiſts, and the painter of it has marked his happy talent, by placing an eye at the end of each finger.

After theſe relations, little need be added to prove the preciſion of the ſenſe of feeling. Some diſorders, however, ſeem to aggravate its powers ſo greatly, that what ſenſations would be pleaſant in health, are now exceſſively acute.

It is natural to inquire into the mode of action of a ſenſe which we find ſo various and comprehenſive, yet ſo minute and ſuſceptible. In mentioning the parts of the body, we juſt hinted at the *nerves*, whoſe magazine we ſuppoſed ſeated in the brain, from whence it detached an extremely ſubtle fluid throughout the body, thereby communicating the *volition* of the animal to his members: theſe we conſidered as the means of ſenſation, the agents in that buſineſs, and to theſe we refer when endeavouring to explain the principles of feeling.

From the medullary ſubſtance of the brain (and the ſpinal marrow) iſſue a vaſt number of whitiſh fibres, ſlightly connected

nected at firſt, afterwards ſomewhat more, yet ſtill looſely; but gradually becoming white, firm, and ſtrong, like ſo many threads running together, and diſtributed over the whole frame; in their courſes, they generally proceed a ſhorter way than the blood veſſels, branching off at very acute angles. Theſe form in ſome places a kind of knotty bodies, called *ganglions*. Whether theſe threads are ſolid or hollow, is debated, and perhaps will continue to be debated, as the extreme fineneſs of their ultimate diviſions precludes our intimate acquaintance with them. In general, the idea of a fluid prevails; and it ſeems to me moſt natural, ſince the exiſtence and agency of many fluids formerly unknown, is now freely acknowledged, and ſince fluids ſeem capable of motion ſufficiently active and impulſive, to produce any effect whatever. With regard to fineneſs of parts, to rapidity, and to power, the electric fluid is an inſtance, and ſeems ſomewhat allied to the nervous fluid by its univerſality, its perpetual fluctuation, and its capacity of being augmented by very ſudden cauſes.

But though this fluid ſhould be granted, how it affects the ſenſorium, or how it is itſelf affected, is obſcure: all we know is, the nerves are the medium of ſuch ſenſations, that while the nerves are gently impreſſed without violence, the ſenſation is pleaſant and agreeable; beyond this advances toward pain; and diſunion of the nerves, or their parts, produces actual pain. That the nerves are alſo the cauſe of motion ſeems likely, becauſe if a branch of them be injured, motion is injured alſo: for inſtance, if thoſe paſſing over the ſhoulder to go down the arm be cut, the arm becomes uſeleſs where their branches

 extend,

extend, notwithſtanding the ſeeming good diſpoſition of the muſcles; and if diſeaſe occurs to the nerves in their more early ſtages, the whole ſide of the body where they extend becomes paralytic, and void of every degree of feeling.

The nerves generally proceed by pairs: Thoſe principally occupied in the ſenſes, from the brain, which yields ten pair; others from the ſpine, which yields thirty pair, diſtributed throughout the lower parts of the body. The ſpinal marrow is properly a prolongation of part of the brain, and is of the ſame nature and conſtituent parts. It is probable, that the nerves are thouſands in number; that to each part of the body is ſent a diſtinct nerve; not that ſeveral ſmaller unite into one larger (like brooks forming a river), but each runs diſtinct from its termination on the ſkin, &c. &c. to the brain; yet the whole, if united, would hardly make a cord of one inch in thickneſs. This is extremely wonderful, but ſupported by numerous microſcopical diſcoveries, whoſe analogy may juſtify the idea.

There is a ſtrange kind of feeling which occurs, after a member, the ſeat of ſuch feeling, is loſt; as after a man has had his leg cut off, he ſtill conceives he feels pain in his toe. Many a Chelſea penſioner thus conceives he feels pain (the cold of winter, or the hardſhips of a march) in his leg, which perhaps he left in America. This may be accounted for by ſuppoſing, that the nerve which uſed to furniſh ſuch information is only taken away in part; I ſay, that only its lower extremity is loſt, and that part which is left feeling a ſimilar ſenſation, the ſenſorium is influenced by the habit which it had acquired,

quired, and for a long time ſuppoſes the ſame effect to proceed from the ſame cauſe.

It is not ſo eaſy to account for the continuance of life and actions in ſome creatures, after they are deprived of their heads, the reſidence of the ſenſorium, and the origination of the nerves. It is well known that inſects will run about in that condition, and a tortoiſe has lived and moved months after it had loſt its brains, and many days after having loſt its head. I can find no other means of accounting for this but ſuppoſing, that the *ganglions* furniſhed the neceſſary ſupply of vitality, and that life was capable of prolongation till they were exhauſted.

Of all the ſenſes feeling is leaſt liable to be deceived: it is not a ſenſe which can act at a diſtance, or receive ideas from afar; its powers are circumſcribed to a narrow compaſs, but within that compaſs it is generally juſt, and tranſmits determinate and forcible ideas. Prepoſſeſſion, indeed, may ſometimes deceive it; where we expect to find a thing, we are ready to think we feel it, though it be abſent. Many a perſon next door to a houſe on fire (or ſuppoſed to be on fire) has thought he felt the wall hot (I have an inſtance in my thoughts). On the contrary, we have authentic accounts which repreſent martyrs as free from the ſufferings their enemies intended to inflict.

We have conſidered the hand as the chief ſeat of feeling in the human ſpecies; its form is admirably adapted to this purpoſe by the nature of its graſp; and as it brings ſeveral points into contact with what it examines, it has ſo many additional

chances,

chances, that if one ſhould err, that error might be corrected by the others. Monkeys, which have hands, make uſe of them as we do, and by this member become a match for their adverſaries, and domineer in the foreſt; for by this they wield a ſtick and beat their enemies, or ſtand out of their reach and pelt them with ſtones; ſo that an elephant himſelf is obliged to relinquiſh the field to a foe that ſtrikes, yet is too diſtant to be himſelf ſtricken. There is alſo a claſs of monkeys whoſe ſeat of feeling is in their tails; with theſe they will often catch animals, &c. and by twiſting it round them, prevent their eſcape; by this too they will ſwing on the branch of a tree, ſprawling the reſt of their ſweet perſons in all manner of attitudes, with great activity, ſecure from falling while ſuſpended by their tails: they will alſo throw themſelves from the top of a high bough, and while falling claſp with their tails a lower one, from which they dangle, grin, and chatter. The ſeat of feeling in the elephant is his trunk, and he poſſeſſes this ſenſe in no trifling degree; with this he will pick up a very ſmall object, and with this, when provoked, he will inflict terrible blows. As to birds, it is ſomewhat difficult to aſſign any ſpecific part as the ſeat of feeling in them, or to determine whether thoſe who have remarkable nerves in their bills, do really ſelect their food by the ſmell or the touch.

On the whole we infer, that the nerves are the medium of feeling; that they are uſually diſtributed throughout the ſurface of the body, and wherever motion is carrying on, of which they are probably the active cauſe; that where they are not, is no ſenſation: where they are few is little ſenſation; where they

they are numerous, ſuperficial, or capable of intimate contact, ſenſation is conſtant, lively, and powerful. Even acceſs of air makes conſiderable impreſſion on them, and muſt be prevented. Nerves are capable of injury, alſo of reſtoration. They ſpread where arteries and veins take their courſes (as in extraneous ſwellings), and are greatly affected by irregularities, which would be little felt in other parts of the frame.

In this laſt remark, I allude principally to the effect of mental paſſions on the nerves, which afford many curious, but inſcrutable phenomena. Joy tightens and braces the nerves, renders them agile and lively; anger ſtill more, and is even ſaid to lighten the body many pounds. Sudden joy has been often fatal, perhaps by detaching too much of the neceſſary fluid; paroxyſms of rage no leſs. Grief debilitates the nerves, relaxes and weakens them; therefore grief is an enemy to life. Perhaps, as ſome paſſions draw away too much of the animal ſpirits, others may prevent the paſſage of a ſufficient quantity, and thereby clog and encumber theſe delicate parts. Extremes either way are dangerous.

Whoever would have his nerves clear, active, and in proper tone, let him command his paſſions, keep his mind cheerful, and avoid anxiety and gloom. But, on the other hand, diſſipation is prejudicial to the nerves; flights and vagaries are no leſs injurious than melancholy depreſſion. Habitual peace of mind, habitual, ſelf-controul, much induſtry, and a little vanity *(fiat mixtura ſecundum artem)* is an excellent preſcription for prevention of nervous diſorders.

LECTURE VIII.

OUR laſt diſcourſe related to a ſenſe whoſe exerciſe was confined to a narrow compaſs, and incapable of acting at a diſtance; but, within its proper limits, exactneſs and perſpicuity amply compenſated for the abſence of excurſive powers: to-night our attention will regard a ſenſe which exhibits many qualities reverſe from the former, unlimited in excurſive faculty, unconfined in its range, but ſubject to illuſion, and eaſily deceived. Such is the ſenſe of SEEING, one of the moſt wonderful inſtances of divine operation; a ſenſe not beſtowed on every creature, not laviſhed on any, poſſeſſed in very different degrees by various tribes of animals, and among mankind alone, were we to look no further, offering great variation.

If we aſk, in what rank of creatures ſight is moſt extenſive, moſt determinate and accurate, moſt powerful, and ſubject to leaſt indiſpoſition? we muſt refer at once to the tribes of birds; and among theſe, it ſhould ſeem, to birds of prey. It is true, the lynx among quadrupeds is proverbial for keenneſs of ſight, and not without reaſon; yet, in extent and accuracy of viſion, he muſt yield to many birds. We ſhall inſtance the eagle in proof of our poſition. The higheſt elevation to which an eagle ſoars, is I believe unknown: but when we conſider

that

Seeing.

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that he inhabits crags of the higheſt rocks, and towering ſteeps of mountainous pinnacles, that from theſe he riſes up to heights which fatigue the eye to trace him, if he does not totally diſappear from obſervation; we are eaſily induced to admit, that a much more extenſive proſpect opens to his view, than any quadruped is ever in a ſtation to ſurvey. What a vaſt ſweep! what a wide extended circumference becomes ſubject to his inſpection! If, when we aſcend to the top of Snowdon, we ſee the adjacent countries lying as in a map, we trace the courſes of rivers, the coaſts of an iſland, the dimenſions of a ſea, the extreme of a remote kingdom;—if, from the top of Etna, we behold the glorious ſun riſe in reſplendent majeſty hours before he viſits parts beneath us; to how much farther may extend the ſight of an eagle, and how many provinces, and kingdoms, and ſtates, may his view include!

Birds which do not riſe high, by their facility in mounting upon trees, enjoy an enlarged horizon: thoſe of the long-necked form have thereby no ſmall advantage, in poſſeſſing the ſeat of ſight ſo high above the level of the plain: this appears in the oſtrich, which, inhabiting deſerts whoſe barrenneſs admits no impediment to his view, by means of the elevation of his head, enjoys a range of viſion far exceeding that of any creature prone by poſition.

Extent of viſion, and accuracy of inſpection, are confeſſedly diſtinct qualities; it is therefore natural to inquire if theſe birds, or birds in common, diſtinguiſh objects at heights in any degree correſpondent to what we have mentioned. We can, on this ſubject, only reaſon by analogy, and conclude from

circumſtances.

circumſtances. Humble as a wren, not ſoaring as an eagle, I preſume not to determine for the ſupreme of birds; but this is certain, that at a height when he is to us inviſible, an eagle will dart down on his prey; that a hawk, a kite, and other birds of prey, when appearing as a mere ſpeck amid the clouds, will, with unerring aim, ſeize the warbler on a buſh; that water-fowl will diſcover fiſh at conſiderable depths in water, and the gannet, or ſolan gooſe (which is ranked among the *boobies*), "will ſoar to a vaſt height, then darting headlong into the ſea, make the water foam, and ſpring up with the violence of his deſcent;" and, though a booby, ſeldom or never miſs his prey. But it muſt be owned, either that he diſtinguiſhes little or nothing beſide his prey, or his other booby qualities exceed the impulſe of ſight; for "one of theſe birds flying over Penzance, and ſeeing ſome pilchards lying on a fir plank, in a cellar uſed for curing fiſh, darted itſelf down with ſuch violence, that it ſtruck its bill quite through the board (an inch and quarter thick), and broke its neck." By ſuch a trap they are often caught at ſea by fiſhermen. But not to birds of prey is this gift confined: domeſtic poultry, eſpecially when engaged in the charge of young ones, are equally obſervant. A turkey hen, for inſtance, will give the alarm to her brood, and keep them in concealment for an hour at a time, when, with all our endeavours, we can ſcarce diſcern the bird which occaſions her terror.

I think it clear, after theſe relations, that quadrupeds cannot vie with birds in the faculty of ſight; nor indeed ſhall we find, on reflection, that they have occaſion for it: for, beſide being confined

confined in the *ſweep* of their viſion, there are numerous obſtacles on a level with them, through which no ſight can pierce; in a foreſt, the ſhadowing thicket, the deep glen, and embowering branches; in cultivated lands, the bank and the hedge, if no other hindrance. On extenſive wilds, indeed, animals have more occaſion for keenneſs of ſight; and certainly that of the antelope is very lively.

We regarded fiſh as having the ſmalleſt ſhare of feeling; we are not equally certain they have the ſmalleſt ſhare of ſight. It ſeems indeed probable, that in ſo denſe a medium as water, eſpecially when foul or agitated by ſtorms, the rays of light, being greatly obſtructed, ſhould conſequently be incapable of depicting images remote from the original object. If this be true, and if the impulſe of light ſuffer conſiderable diminution even at moderate depths (which is likely from circumſtances noticed in a diving-bell), then the bottom of the ſea, where very deep, is cloſely allied to the ſhadow of darkneſs. It ſhould ſeem to be, in reality, occupied by creatures to whom abundant light were uſeleſs; who living on prey which came within their reach, rather than ſeeking after it, were obliged for their maintenance at leaſt as much to feeling as to ſight. Fiſh of the active kinds, though occaſional viſitants below, may nevertheleſs be attentive to what paſſes above; at leaſt we are ſure, that ſharks will come from great depths to ſeize unhappy ſwimmers: they are ſometimes ſeen, from as deep as our eyes can diſcover them, making right for the object of their purſuit, as if they had long had him in view. Many kinds of fiſh are void of every appearance of organs for

the exerciſe of ſight: others, though not void of organs, ſeem to poſſeſs but feeble and indiſtinct preparations for the ſenſe, and to enjoy the ſenſation in a very inferior and reſtricted manner.

We have hinted at the *teleſcopic* ſight of birds, whereby they diſcern very remote objects; let us now conſider the *microſcopic* ſight of inſects, whereby their viſual powers are ſtrengthened beyond conception. I imagine that inſects in general (for there are exceptions) ſee but a ſmall diſtance, a few feet or inches, before them: but within the reſpective diſtances, which I may call their range of viſion, I ſuppoſe they ſee objects very diſproportionately magnified; that a hair is to them as a tree to us; that their fellows are, in their eſtimation, tall as grenadiers, often perhaps gigantic; that their cells are magnificent palaces, their enjoyments on a great ſcale, replete with convenient elegance, in the immediate taſte; and what not? Raillery apart, I incline to think, that the lower we deſcend in ſize and apparent power, among the tribes of inſects, the greater are ſome of their properties; and as, by actual diſcoveries, we know the principles of optics to be unlimited, it ſeems not abſurd to ſuppoſe their higher degrees beſtowed where intenſity ſeems likely to compenſate for the abſence of generality. If I recollect right, the famous LEUENHOECK attempted to uſe the eye of an inſect for a microſcope, and found it an amazing magnifier, though he could not readily adjuſt it: but this I may ſay, if their food bear a proportion to them, as that of larger animals, what muſt be the power of an inſect's eye, who is himſelf the *thirty thouſandth*

thouſandth part of an inch in length, that he may chaſe his prey! his atomical maintenance!

There is a ſtrange power attendant on ſight, which, if we may rely on ſome averred facts, is remarkable in the rattle-ſnake, that charms its prey into its mouth. The inhabitants of Pennſylvania are ſaid to have opportunities of obſerving this ſtrange faſcination every day. The ſnake is often ſeen baſking at the foot of a tree, where birds and ſquirrels make their reſidence. There, coiled upon its tail, its jaws extended, and its eyes ſhining like fire, the rattle-ſnake levels its dreadful glare upon one of the little animals above. The bird or the ſquirrel, whichever it may be, too plainly perceives the miſchief meditating againſt it, and hops from branch to branch, with a timorous, plaintive ſound, wiſhing to avoid, yet incapable of breaking through the faſcination: it continues for ſome time its feeble efforts and complaints, ſtill approaching lower and lower toward the bottom of the tree, until, at laſt, as if overcome by the potency of its fears, it jumps down directly into the throat of its frightful deſtroyer.

This, if true (for it is debated), is wonderful: yet perhaps not altogether incredible, when we recollect the power of the eye among mankind. Hags and witches were formerly accuſed of injuring their neighbours "by evil eyes," whoſe nefarious ſpells defied the remedies of phyſic. In our days, much greater effects of irreſiſtible faſcination accompany the glances of eyes bright and ſparkling: not the incantations of Medea herſelf ever equalled in *charms* an aſſembly of Britiſh Ladies.

Without appealing to unhappy, becauſe guilty, inſtances of faſcination by the power of the eye, I ſhall juſt hint, that very forcible ideas are unqueſtionably received by this organ. A perſon ſtanding very high (on a ladder ſuppoſe) is ſafe while he looks ſtraight forward, but is in danger of falling if he look down. Thoſe unuſed to ſcaffolding, find their head become giddy (*ſwim* as they expreſs it), and their ſenſes fail them. Very ſteady fixure of the eye, while a perſon is in progreſſive motion (as in a boat) very greatly confuſes the mind for the time, and often occaſions ſwooning. I recollect a melancholy inſtance of a young lady on her voyage to India, who ſtanding in the ſtern-gallery of the ſhip, and very earneſtly watching a ſhark which was baſking in the water, by ſome ſuch *deliquium* actually fell from the gallery into the water, and became his prey. Aſtoniſhment uſually enters at the eye, and often ſeizes ſo ſtrongly, as to ſuperſede the power of motion. In fact, whether we regard a creature which alarms us, we look at his eye (and a lion is affirmed to be vanquiſhed by the ſteady aſpect of the human eye), or converſe with a friend who delights us, we look at his eye, or wiſh to attract the notice of another, whether at a little diſtance, or not, we look at his eye. In fighting, we watch the eye of our adverſary. In civility and courteſy, in affection and eſteem, the eye is the organ of our ſtudy. It ſeems to be a principle acting at a diſtance, as well attractively, as repulſively, but whether to the degree affirmed of the rattle-ſnake, I will not determine. In our own country, the fox is ſaid to bring down a cock or hen from the rooſt, merely by the ſteady glare of his eyes, confuſing by

his ſtare (for ſo I account for it) the creature on which he fixes his ſight; and this ſeems to ſupport the hiſtory of the ſnake.

Sight is not generally diſtributed over the frame, as we obſerved of feeling, but reſtricted to certain organs; yet, becauſe reſtricted, is not therefore ſparingly beſtowed. I do not recollect any animal poſſeſſing one eye only; ſight, where neceſſary in any degree, is more or leſs indiſpenſable; therefore, to provide againſt its deprivation by accident, benevolent wiſdom has contrived, that it ſhould not be totally loſt at a ſingle ſtroke: likewiſe, as demonſtrating its indiſpenſability, it is varied in powers, according to the ſituations of creatures, in the conſtructions and numbers of the organs engaged, in their poſitions, and in their properties. It is true, that certain water inſects have been named *monoculi* (one-eyed), yet on repeated examination, their apparent one eye is found to be compoſed of four. The ſeat of ſight is in the head, for reaſons which we have formerly hinted, as being more immediately connected with the ſenſorium, where the united teſtimony of the ſenſes contributes to mutual correction; and, in moſt animals, that it might enjoy the advantages ariſing from the elevation of that part, and from the powers of extenſion belonging to the neck.

Is ſight accurate, or inaccurate? When compared with the determinate judgment of feeling, ſight muſt be conſidered as liable to frequent deception; it is extremely reaſonable to ſuppoſe, that what embraces objects ſo numerous, ſo varied, ſo remote from each other, capable of endleſs combinations, and intricacies,

intricacies, ſhould ſometimes miſtake. What embraces all at the ſame time, and tranſmits ideas of each at the ſame inſtant, may be pardoned, if it form incorrect opinions on ſome of them. That multiplicity ſhould include error, and prevent diſcriminating accuracy, is not ſurpriſing, eſpecially when we recollect the medium through which this ſenſe is required to act—the diſtances to which it extends—the ſimilarity of ſome objects to others, and—the arts of ingenuity, whoſe ſtudies have been uniformly directed to the delight, by deception, of this particular ſenſe.

But there are alſo inherent inaccuracies belonging to this ſenſe, and reſulting from the number and nature of its organs. From the number of our eyes, we may, without heſitation, admit that we ſee every object double, *i. e.* that each eye tranſmits to the ſenſorium an idea of the object ſeen. We find alſo, that each eye does not ſee preciſely the ſame points of view as its fellow; for, by merely taking advantage of ſome ſteady object near us, and ſurveying firſt with one eye, then with the other, what may be called its *back ground*, we perceive the apparent place of the object changes, and a conſiderable *parallax* enſues. In fact, by the relative ſituation of the eyes, we ſee, as it were, partly *round* what we inſpect.

Beſide this, there is in each eye, a ſpot deſtitute of viſion: CHESELDEN relates a hiſtory of a gentleman, who having loſt one eye, in paſſing through a hedge, received in that remaining, a wound from a thorn, in that particular ſpot where it was to the ſingle eye inviſible, though it would have been viſible to the

the other eye, if he had poſſeſſed it. This circumſtance proves the mutual obligations of the eyes to each other.

Another imperfection of ſight is, that objects are actually *ſeen* inverted; rays from thoſe above appear below, rays from thoſe below appear above, correſpondent to the effects of certain kinds of lens glaſſes, or to rays paſſing through a crevice into a dark chamber: and I think I remember a ſtory of an idiot, who *drew* all his figures *topſy-turvy*, not having accurately corrected this ſenſe by the uſage of others.

Nor is ſight capable alone, of determining diſtance, or judging of magnitude; all rays of light which enter the eye, have equal effects in painting there a picture, that picture therefore is deceptive, till the judgment is regulated by repeated information from other quarters. This is notorious in children, who conſider all things as within their graſp: and with regard to very extenſive diſtances, as thoſe of the heavenly bodies, ſight is always inaccurate in its eſtimation. The rainbow is a deception of ſight, whoſe principles we have explained; no ſuch coloured arch actually exiſts in the cloud, but is illuſory: nor are leſs illuſory the ſparkling rays which in the dark ſurround a candle, a ſtar, or other luminary. Theſe irradiations are accounted for, by conſidering the number of rays which paſs through the eye-laſhes, and are by them divided into parcels, or reflected from the eye-lids, of which only ſome reach the ſeat of viſion: any tube prevents them, by preventing the acceſs of ſo many falſe rays, or they may be checked by a pin-hole in a card. In fact, they only appear at a diſtance; on cloſe inſpection, we are convinced of their non-exiſtence, they are a deception of ſight.

There

There are other deceptions of ſight, which are very rare, and highly curious; ſuch is the fairy Morgana of Sicily, in which the ſea aſſumes the appearance of fields, mountains, cities, and a variety of objects unlike itſelf: we have an account of a ſimilar viſion ſeen in Greenland,—a climate ſufficiently different from that of Sicily. Theſe are underſtood to be reflections from the atmoſphere (at that time unuſually denſe) of whatever objects are behind the ſpectator, even trees, animals, &c. But ſimilar appearances ſometimes ariſe from the peculiar ſtate of the atmoſphere ſeen *through*, and theſe ſeem allied to mock ſuns, halos, and other (ſeemingly) celeſtial phenomena, which, like the former, are not realities, but viſionary illuſions. I have elſewhere ſuggeſted a few other particulars wherein ſight is liable to deception, as in the courſe of a ſhip, when objects around us furniſh fallacious comparative proportion, lamps at a diſtance, ſeen in obſcurity, and ſome others. Theſe we introduced in our ſecond ſet of Lectures on the Arts of Deſign.

We come now to the MODE of ACTION, adopted in the ſenſe of ſeeing. To underſtand which with more effect, we muſt recollect ſomewhat of our remarks on the nature of Light, by whoſe agency this ſenſe is produced.

We conſidered light, as being an extremely ſubtle, elaſtic, attenuated, but vigorous fluid, whoſe impulſe, though inſenſible to us, yet produces very remarkable effects. This fluid is weakened by *divergence* of its rays (as in the inſtance of the moon light), but is ſtrengthened by their *convergence*. Add to this,

this, the ſelf-evident power of contraſt, and we have the principles on which the eye is conſtructed.

Contraſt, you know, heightens by its oppoſition every effect; black upon white is blacker, white upon black is whiter, red upon blue is redder, blue upon red is bluer, than without ſuch oppoſition:—this conſidered, we infer that, to give light its full force, it muſt be contraſted by darkneſs. The ſeat of ſight is therefore placed *deep*, in a hollow, where darkneſs may naturally be expected, thereby rendering a little light more efficacious than much in open expoſure.

Light, at that degree of ſtrength which ſurrounds us, we have no reaſon to think capable of affecting any part, even of the tendereſt nerves; it muſt therefore be converged, or condenſed, or ſo contrived, that more than a natural proportion of rays ſhould unite, in forming the requiſite impreſſion; and this is the mode adopted by Infinite Wiſdom. A certain number of rays (ſay twenty) would naturally ſtrike againſt the eye, and enter it; but, if theſe are, there, by any means, directed to fall upon a ſurface equal to only one twentieth part the ſpace through which they entered, it is evident their ſtrength is twenty times what it would have been, had they continued as they were. I ſay, they affect the part they ſtrike, twenty times as ſtrongly as common light. This is ſo notorious in the caſe of teleſcopes (and the eye is a natural teleſcope), that it needs no enforcing.

Let us now examine a little the mechaniſm of the parts which produce this effect. We have ſaid the ſeat of ſight is *deep*; in fact, the eye is placed in a bony orbit, which affords

at once ſecurity and convenience. This orbit is filled with a looſe fat, as a ſoft medium for the eye to reſt on, forming alſo a properly-ſhaped, but not inflexible, ſocket for its motions. In the upper and outer part of the orbit is ſeated the lachrymal gland, which furniſhes a water to cleanſe and moiſten the ſurface of the eye, which we often *ſpread*, by cloſing the eye-lids, though without that deſign. The eye is orbicular, for readier motion every way. The firſt membrane of this orb *covers* the white of the eye, and alſo *lines* the two eye-lids: by thus *returning*, it cloſes up all paſſage to the back of the eye. As part of the internal contents of the eye is liquid, it is ſurrounded by a ſtrong caſe to contain them ſafely; this is in one part tranſparent, and there called the *cornea*, but elſewhere the *ſclerotica*. Under the cornea (or horny tranſparency) lies the *iris*, which is an opake membrane, differing in colour in different perſons: the middle of the iris is perforated, and this perforation is called the *pupil*; immediately under which lie the *ciliary* proceſſes, in radii, whoſe contraction dilates the pupil, whereby it tranſmits more light. The pupil cloſes (to exclude light) by the circular fibres of the iris, its proper membrane. Under the ſclerotica is a membrane called *choroides*; and under the choroides lies the *retina*, which is an expanſion of the optic nerve (like net-work in appearance), upon which the rays of light ſtriking, occaſion the ſenſation of ſight.

In the membranes mentioned, we find no preparation for converging the rays of light, without which we have aſſerted its inſufficiency; theſe we diſcover in their contents, which are, three humours; the *aqueous*, the *cryſtalline*, the *vitreous*.

treous. The firſt not only defends the ſecond, but ſerves as aſſiſtant to its motion. The cryſtalline (rather ſolid than liquid) is in ſhape a depreſſed ſpheroid. The vitreous humour lies behind the cryſtalline, and fills the greater part of the eye, *i. e.* from the interior ſurface of the cryſtalline, to the retina. Let us now examine the uſe and properties of theſe humours.

Light, we obſerved, when entering a denſer medium from that in which it was moving, was attracted, and drawn out of its courſe (as out of air into water or glaſs): this effect it experiences, when ſtriking on the cornea, whoſe refraction equals that of water (four to three): here is a firſt advance toward convergence of the rays of light; but this ratio carries its focus far *beyond* the retina, where only it can be efficacious: therefore, the cryſtalline converges them yet more, and they are yet more preciſely directed by the vitreous humour, till they fall exactly on the retina in their full force, and produce perfect ſight. There are perſons whoſe ſight is imperfect, by reaſon of the rays of light forming a focus *before* the retina, as in other perſons *behind* it. The retina being, as we ſaid, an expanſion of the optic nerve, tranſmits its impreſſions to that nerve, and by it to the ſenſorium. If, as we hinted in our laſt Diſcourſe, every part has its nerve, ſhould we not rather ſay the retina is compoſed of thoſe ſmaller nerves, which in the optic nerve appear as one bundle, and theſe ſmaller nerves tranſmit each of them its intelligence to the ſenſorium, where their effect is united? May we hereby account for the exiſtence of thoſe *ſpectra*, or images of objects

ſeen

ſeen *after* we have excluded them, by ſhutting our eyes? an effect remarkably attendant on luminous objects.

This accurate and curious contrivance ever has excited wonder and admiration; in the preſent aſſembly, I have no need to expatiate on ſuch becoming ſentiments; wherever are good ſenſe and reflection, ſuch ſentiments ariſe naturally, and with greater effect than thoſe ſuggeſted by art or declamation. Yet give me leave to remark ſome of the moſt ſtriking peculiarities attendant on the eye. 1. Sight does not depend on our wills; while our eyes are open, we muſt ſee: but, if we are at any time inclined to forego this ſenſe, we have the power, by cloſing our eye-lids. It ſhould ſeem by this proviſion, which, when about to ſleep, we always make uſe of, that ſight is the moſt active of the ſenſes; for the ear remains open, yet we ſleep, and ſometimes, feeling not carried to pain, ſcarce awakes us: but the eye ſeldom opens without rouſing the whole perſon. 2. The inſtinctive attention of the eye-lid, to cloſe and defend the important organs of this ſenſe; this is ſo inſtantaneous, that it is performed before any commands to that purpoſe arrive from the ſenſorium. Happy for us, that hereby thoſe leſſer and ſcarce viſible motes, which almoſt elude our ſight, are prevented from doing that miſchief which otherwiſe they might. 3. The regular and ready adjuſtment of the pupil to that degree of light which ſurrounds it: this alſo is involuntary, and proceeds without our determination; but not ſo rapidly as the former principle; for out of darkneſs entering ſudden light, or out of light entering ſudden darkneſs, we find ourſelves for a little time unfit for ſight in either. 4. The

happy

happy adjuſtment of the interior humours of the eye to the diſtances of objects, or to that intenſity which inſpection of them requires. 5. The projection of the cornea *before* the true *ſweep* of the eye-ball, whereby an enlarged extent of viſion is gained *laterally*, without injuring the accuracy of that which is direct; alſo, its hard, though tranſparent ſubſtance, whereby it is leſs ſenſible of injuries, and more capable of defending the aqueous humour. It is obvious alſo, to remark the well fortified ſituation of the organs of ſight, their almoſt ſurrounding bony defences; nor are leſs remarkable the number of muſcles requiſite to the motion of the eye, above, below, around; thoſe to the eye-lids; the conſtruction, ſituation, and uſes of the eye-laſhes alſo demand acknowledgment: in ſhort, whatever contributes to the action or perfection of this ſenſe, is extremely ſagacious in contrivance, accurate in effect, and happy in application.

Such are the general principles of ſight: that they ſhould be adapted to various ſervices, may be expected, from the wiſdom which appears in their very exiſtence. For inſtance, the pupil is round in men, and in animals which are the prey of both birds and beaſts, this form permitting viſion every way alike; but in graminivorous beaſts, that are too large to be the prey of birds, it is *oblong horizontally*, which fits them to view a large ſpace on the earth; while cats, &c. which climb trees, and prey as well on birds as animals that hide in the earth, have their pupils *oblong perpendicularly*, as fitteſt to look upward and downward at once.

In men, the *choroides* is of a ruſty dark colour, abſorbing the rays of light, and preventing reflections from it, which might

confuſe regular viſion; but beaſts of prey have this membrane white, and by its reflections are enabled to ſee with little light. Brutes, which feed on graſs, have this membrane of a bright green; and this makes graſs more ſtrongly viſible to them. Their ſight is diminiſhed in general accuracy and truth, but augmented in ſtrength toward certain objects.

Birds have, no doubt, ſimilar variations: ſome are provided with an external membrane, called *nictitans*, which covers the whole eye: this not only defends the parts, but prevents the ill effects of that glare of light to which they are often expoſed (as the eagle); and this varies, ſomewhat like the form of the pupil, as juſt hinted. Some creatures have a membrane above, and another below, which, meeting in the middle of the eye, may either quite cloſe it, or leave a crevice for the paſſage of light; others have only one membrane at top or at bottom; and in ſome it is placed on one ſide: the claſs of birds, which furniſhes inſtances of ſight wonderfully accurate, furniſhes others, which are ſo tender-eyed, that open day confuſes them. I ſuppoſe that owls, and other nocturnal birds of prey, are in much the ſame circumſtances (in greater degrees) as beaſts of prey: the ſame reflections of rays, the ſame colours of parts, the ſame repetitions, which enable a little light to be ſufficient by night, are diſtreſſing by day; and tranſmit a huddled variety of images, all indiſtinct and perplexing. No wonder then an owl by day-light will ſit on a tree, ſurrounded by ſmall birds, and ſuffer all manner of indignity, without attempting to defend himſelf, unleſs

leſs winking, blinking, and gaping, may be termed defence: but once come twilight, the caſe is altered, and woe to the negligent bird that remains within reach. Are not owls, &c. *forced*, by this circumſtance of viſual diſability, to ſeek refuge in ſequeſtered darkneſs during day-light? May ſomewhat like this account for thoſe perſons who can ſee well only by moon-light?

To proceed:—the cryſtalline humour is capable of a little variation in form, and actually is varied, when we look at objects very remote, or at others near. It is ſaid alſo, that fiſh lower this humour when out of water, and elevate it in water. (May not birds that ſoar high do ſomewhat of the ſame?) This humour in them ſeems a perfect ſphere, by this form compenſating for the nearneſs of its refracting power to that of water. Fiſh have their pupils larger than land animals, to admit all the light poſſible.

We ſhould remark of the optic nerve, that it does not enter the eye exactly *centrally*, but nearer the noſe; which is of manifeſt advantage, for had it pierced the eye in the axis, the middle point of every object had been inviſible, and where all things conduce to render viſion perfect, there we had not enjoyed viſion at all. The nerve to each eye is ſuppoſed to tranſmit the images of objects ſeen; it is no ſingular caſe for diſeaſe to produce *double* ſight, which is long in cure. The optic nerves of fiſh ariſe from oppoſite ſides of the brain, and croſs without uniting: theſe creatures being incapable of ſeeing the ſame object with both eyes. Probably the eyes are

entirely independent of each other; but why the nerves croſs is not known.

We have heretofore hinted at the variation, in number, of the organs of ſight among creatures; from ourſelves, which have but two, to inſects, which have thouſands. We know little of inſect viſion, beſide what I have offered, or what ideas they have of objects who ſee ſo many, or whether they know it to be but one ſeen repeatedly: we are ignorant what effect the ſight of objects, by the different aſpects of his two rolling eyes, has on the cameleon, who looks at once forward and backward, upward and downward, directing one eye this way, the other that way. We are ignorant of much that relates to this ſenſe; but we obſerve, that the eye is conſtantly ſo placed as to obſerve food, and to warn of danger. Flat fiſh expect enemies from above; this way then ſtands their eye: inſects are expoſed all round; their eyes, therefore, project greatly before their head every way. In fact, of ſome their heads ſeem almoſt all eyes, that ſome or other of their *ſights* may do its duty.

There is little need for an eulogium on the ſenſe of ſight; our perpetual uſe of it is its higheſt eulogium: without it, what were the celeſtial-tinted atmoſphere which ſurrounds us, what the verdant carpet which is our natural reſidence, what the bright beams of morning, or the glowing tints of evening; what the yet brighter beams, and more glowing tints, where nature's utmoſt art perfects the principles of colours; by contraſt, yet union, of delicacy with depth, of indetermina-

tion, with preciſion; by choice of pleaſing tints, heightened by variety, and purity;—in vain, without ſight, were BEAUTY of form or colour; vain were the charms we moſt admire; and were theſe vain, what could ſeem grateful? or what compenſate for enjoyments loſt, in loſing the ſenſe of ſight?

LECTURE

LECTURE IX.

LADIES and GENTLEMEN,

WE conſidered, in a late Diſcourſe, the advantages of VOICE, as highly important and beneficial: by this we expreſs the ſentiments of our minds, the ſenſations of our perſons, joy or ſorrow, exultation or grief—the tender accents of love and friendſhip, of ſympathy and compaſſion:—the fierce howls of rage, of diſappointment, of deſpair, are diſtinguiſhed by their influence on the voice; but of what uſe were voice without an auditor?

HEARING is among our moſt valuable poſſeſſions, is indeed leſs extenſive in its range than ſight, yet frequently ſurmounts obſtacles which hinder the exerciſe of that ſenſe; and well for us it has this power, as hereby we receive important informations, which might otherwiſe eſcape us.

Sound is the immediate object of hearing, and by its divergence extends in every direction, viſiting a thouſand with the ſame eaſe as one, and freely communicating tidings, whereever attention excites an auditory. Sound travels rapidly, and in a few ſeconds of time relates what paſſes at a very conſiderable diſtance; hence a ſingle bell alarms a multitude; and hence

Hearing.

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hence the report of a cannon is fraught with general information.

Sight is the moſt extenſive ſenſe; hearing is the next: we ſee even to diſtant worlds, but we hear nothing of what paſſes there; for we can direct ſight otherways, we can avoid regarding thoſe or other objects; nay, we can totally preclude all objects, and forbid their making the leaſt impreſſion on us; but we cannot partially forbid hearing; had we then been forced to hear what is totally unconnected with us, and alien from us, it would have been perplexity to no purpoſe. On the ſame principle, extenſion of this ſenſe beyond the limits we find aſſigned it, would produce inceſſant confuſion. What a ſtrange medley of heterogeneous principles would moleſt us, what impertinent intruſions would diſtract us from our immediate concerns, were our hearing too ſharp, too extenſive, or too powerful! The communicative whiſper would then be impracticable, the very relation of a ſecret would deſtroy its ſecrecy. It might reſemble Sir JOHN MANDEVILLE's account of *frozen words*, in his voyage to the North Pole; theſe, when *thawed* by a change of weather, diſcovered all the ſentiments uttered in the veſſel during the froſt, and were a *ſweet* compoſition of vows, oaths, and execrations, repinings, wiſhes, and diſcontents—for few were the expreſſions of kindneſs, reſpect, or devotion.

Sounds are more or leſs *intenſe*; in proportion to their intenſity they more forcibly agitate the ſurrounding atmoſphere; a forcible agitation extends its effects further than a bare feeble motion of the atmoſphere; and thus we account for the diſtance

tance to which ſounds travel: that when this aerial impulſe is nearly ſpent, it ſhould furniſh a very weak ſound, is natural; that when we are nearer to the origin of the ſound, where it has travelled little, and its impulſe is vigorous, it ſhould be ſtronger, is alſo natural: thus we account for the *ſtrength* of ſound. There is alſo a *heightening* and *deepening* of ſound, as in the ſcale of muſic, where *Gamut* is the ſtandard note: this is explained, by conſidering the relative vibrations of the higher and lower ſounds. The quickeſt vibrations (of a ſtring for inſtance) are the *higheſt* or *ſhrilleſt* tones; the ſlow vibrations are *deepeſt* or *graveſt*. In ſtringed inſtruments, the lengths, magnitudes, and tenſion of the ſtrings, influence their ſounds.

To produce diſtinct ſound, requires thirty vibrations in a ſecond of time; leſs will not become audible, more becomes confuſed; extreme rapidity (as a thouſand vibrations in a ſecond) forms a mere whiz, or confuſion. All ſound ſhould ſeem to originate from vibration. If a perſon paſs briſkly his wetted finger round the brim of a drinking glaſs, by its preſſure he will cauſe tremors or vibrations in the glaſs, which, in conſequence, will ſound, and continue ſounding, while the motion of his finger continues; this may be carried to ſuch rapidity as to break the glaſs. The ſame principles account for the tones of wind inſtruments, which ſound by the vibrations of a column of air, contained within them, and actuated by the voice or breath. As in ſtrings, the ſhorteſt are the high notes, ſo in a flute, the ſhorteſt holes emit the higheſt ſounds. Whether ſound really originates from the ſtring, or from the *re-action* of the air diſplaced by the vibration of the ſtring, has been doubted:

doubted: probably from the latter; hence the ſound of a cannon is ſo vehement, becauſe, the vacuum occaſioned by its firing, being nearly perfect, the ſurrounding air ruſhing with great violence, to ſupply this vacuum is proportionately agitated. Somewhat like this, in miniature, occurs on re-admiſſion of air to the exhauſted receiver of an air-pump.

Do all creatures poſſeſs the ſenſe of hearing? Certainly not: yet in proportion to their numerous varieties, we may conſider it as a ſenſe rarely with-held. Thoſe void of ſight, are often void of hearing alſo, which ſeems of little value, where the moſt extenſive ſenſe would be either uſeleſs or injurious.

It has been debated whether fiſh hear: but with regard to the major part of the active kinds, at leaſt, it is conſonant to reaſon to ſuppoſe they do, as well becauſe we find organs ſeemingly adapted to the ſenſe, as becauſe violent ſounds affright, and perhaps *ſhock* them. If I miſtake not, lobſters are ſaid to caſt their claws at the noiſe of thunder, as alſo at the report of a great gun, which we know reſembles thunder; and a ſalute is ſaid to be a frequent threat by men of war to lobſter boats, when purchaſing thoſe fiſh, to inſure good ones. I think alſo, that few fiſh, if any, appear on the ſurface of the waves during a thunder-ſtorm; and beſide what has been ſaid of the firing a muſquet frightening a ſhoal of herrings, it is certain that a ſtone, &c. thrown into a rivulet, out of ſight of fiſh, will yet diſturb and diſperſe them. But we are to remember in what ſound conſiſts; that it is a pulſation of the ſurrounding medium, affecting our nerves with ſenſations which, tranſmitted to the ſenſorium, we call ſound; ſuch

pulſations in water, proportionate to the denſity of that medium, and to other circumſtances, probably affect fiſh, as aerial pulſations do ourſelves. Water is known to tranſmit ſound, ſince noiſe made at a conſiderable depth, has been heard in air by thoſe who attended to it; as has been experimented by divers ſtriking ſtones together under water.

As to beaſts, we regard them as poſſeſſing this ſenſe in different degrees; in ſome it is extremely acute, and impreſſive, and in fact is a ſubſtitute for thoſe exquiſite powers of other ſenſes, by which other creatures trace their prey. This we have hinted in the lion; we may ſay, in general, wherever is voice, is alſo hearing; birds of ſong, therefore, are conſidered as poſſeſſing this ſenſe in great perfection, *i. e.* great accuracy of judgment in determining upon tone. There is another kind of perfection, *that* relating to diſtance, which, probably, appertains to birds of prey; and in this, I think it likely, they are unrivalled. It ſeems ſcarce probable, that the lion himſelf can hear ſo far as theſe kinds of birds.

But, though we ſaid ſong birds are extremely accurate in determining between tones very little higher, or lower, than each other (as we gather from their modulation of tones with great nicety), yet, probably, the human ear is the moſt exact judge in this matter. Muſicians will diſtinguiſh between tones, which to unpractiſed ears are alike, and blind perſons (eſpecially) often aſcertain by their preciſe judgment of ſounds, many things, perſons, or places, which to thoſe leſs attentive require inſpection. As inſtances of fallacious judgment in birds, Parrots, which are notorious for loquacity, will often talk

to

to themſelves, and miſtaking their own voices for thoſe of perſons to whom they have been accuſtomed, will hold down the head, hold out a claw, dance, and do many other things, as directed by *their own bidding*.

This reminds us of the utility ariſing from the providential differences of voice, not only among mankind, but among animals alſo, whereby parents diſtinguiſh their young from among many, and the young diſtinguiſh their parents. What ſlight, yet determinate, variations among ourſelves contribute to this, are probably at leaſt as effectual among animals. No two ſheep *baa*, nor two cows *low*, exactly alike; nor do hens *cackle*, or ducks *quaack* preciſely ſimilar.

The ſeat of hearing is fixed near the ſenſorium, for the ſame reaſons as ſight is, and, like ſight, has more than one organ, as well for preciſion, and accuracy of information, as for ſecurity againſt its deprivation at a ſingle ſtroke. Many perſons are deaf with one EAR, but hear with the other.

The principles adopted in conſtructing the ear, are not totally different from thoſe adopted in the eye; in both, the ſeat of the ſenſe is *deep*, and in both the active principle is *converged* to a focus; but they differ, in that the rays of light are converged *directly* (becauſe light paſſes in ſtraight lines); whereas the rays of ſound are conveyed by (and after) repeated reverberations, becauſe aerial undulations extend all around, and act in every direction. The general conſtruction of the ear, therefore, is externally broad, extenſive, and capacious, that it may collect as much ſound as poſſible; but narrowing by degrees, that it may condenſe the ſound it has collected; not

too ſuddenly, that would ſhock us, nor too ſlowly, that were to admit the poſſibility of its being often too late, to excite the mind toward ſubjects requeſting aſſiſtance.

Tracing the progreſs of ſounds from the external parts of the ear, to where they principally raiſe ſenſations, we find a paſſage of unequal dimenſions, leading internally toward the brain; this paſſage is lined by a glandular membrane, which furniſhes what is called the *cerumen* or ear-wax, whoſe uſe is to prevent the paſſage of inſects, &c. into the ear, and to keep the external air from injuring it; for as we cannot cloſe our ears, and have no means of excluding offenſive animalcula (as the eye-lids do from the eye), this bitter ſubſtance anſwers the purpoſe, and that at all times.

Proceeding in the auditory paſſage, we find the *membrana tympani*, or drum of the ear, which is a fine membranous expanſion, extended on a bony ridge, almoſt circular; this membrane does not entirely cloſe the paſſage, but has on one ſide a ſmall aperture covered with a valve. Though highly beneficial to the ſenſe, this membrane is not the ſeat of hearing. Behind it is a cavity, containing three very ſmall bones, denominated from their reſemblances, as the hammer (*malleus*), which is extended into the middle of the tympanum, and is at its other end articulated to a bone called the anvil (*incus*), which is alſo articulated, by the intervention of an exceeding ſmall one called *orbiculare*, to a fourth bone, called the ſtirrup (*ſtapes*); theſe are uſually regarded as the *ſine quâ non* of hearing. They tighten, or relax, the membrana tympani without our knowledge, much on the ſame principle as the pupil

of

of the eye is enlarged, or narrowed, and much to the ſame purpoſe; by extending the tympanum, increaſing the effect of a little ſound, by relaxing the tympanum, deadening the force of ſound when too powerful. From the cavity behind the tympanum, is a paſſage to the mouth, through which ſounds are, under certain circumſtances, tranſmitted to the auditory paſſage, without the interpoſition of the tympanum. This cavity alſo contains a portion of air. To the ſtapes or ſtirrup, belongs a muſcle, whoſe duty is to pull the ſtapes off from a ſmall hole, which it otherwiſe covers; this hole, and another near it, leads into a cavity called the *veſtibule*, which leads into other cavities called the *labyrinth*; compriſing the *cochlea*, which (like a ſnail's ſhell) forms two turns and a half ſpirally, and is divided into two parts by a ſpiral *lamina*, or thin diviſion. A very delicate membrane lines the cavity of the labyrinth, and is an expanſion of the auditory nerve (as the retina is of the optic nerve), and the primary part of the organ of hearing. There are other openings, and other cavities viſited by nerves, which tranſmit the ſenſations they receive from ſounds to the brain.

What a ſurpriſing ſtructure have we been deſcribing! What care, not only that weak ſounds ſhould have their effects, but (eſpecially) that ſtrong ſounds ſhould not be injurious! and this is moſtly to be apprehended, as, by their violence, they might burſt the tympanum. To guard againſt this, bombardiers or others, when firing very large cannon, fill the external ear with ſomewhat ſoft to cloſe it; but if this ſubſtance ſhould by any means enter the paſſage, it is very

very dangerous. Obſerve the ſkill manifeſted in the incloſing a ſmall quantity of air, free from acceſs of external air, conſequently unaffected by atmoſpheric variations, for being the medium of ſound, air could not be diſpenſed with even here. Obſerve, that one hole is cloſed by the ſtapes, another is open, which is a contrivance happily adapted to the tranſmiſſion of more or leſs ſound, according as excited by attention.

The poſition of the membrana tympani, is in men and brutes, almoſt *horizontal*; but inclined toward the external paſſage, this being the beſt ſituation to receive ſounds, great part of which often is reverberated from the earth. In men and brutes, it is *concave* outward, but in birds *convex* outward, ſo as to make its upper ſide nearly perpendicular to the horizon: which ſeems adapted to the reception of ſound when high in the air, where little, if any, is reverberated.

Hearing, like ſight, gives us notice of remote objects, and is ſubject to ſimilar errors. We have by it no diſtinct intelligence of the diſtance from whence a ſound is heard; a great noiſe far off, and a ſmall one near, produce the ſame ſenſation; and, unleſs informed by ſome other ſenſe, we cannot diſtinctly tell whether the ſound be great or ſmall, nor till we have learned by experience, that the particular ſound we hear, is of a peculiar kind, can we judge of its diſtance.

It often happens, that perſons hear differently with one ear from the other; theſe have what is called, by muſicians, a bad ear. Mr. Buffon, after many trials, always found that their defect in judging of ſounds, proceeded from the inequality

quality of the ears; receiving by both, at the ſame time, unequal ſenſations, they form an unjuſt idea; as they hear falſe, they alſo, without knowing it, ſing falſe. Theſe perſons alſo frequently deceive themſelves with regard to the ſide from whence a ſound comes, generally ſuppoſing it to come on the part of the beſt ear.

Hearing is a much more neceſſary ſenſe to man than to animals. With theſe it is only a warning againſt danger, or an encouragement to mutual aſſiſtance. In man, it is the ſource of moſt of his pleaſures; without which, the reſt of his ſenſes would be of little benefit. A man born deaf, muſt neceſſarily be dumb; and his whole ſphere of knowledge be bounded by ſenſual objects.

As it would be unpardonable, in a diſcourſe on hearing, to omit the pleaſure this ſenſe receives from muſic, I ſhall introduce a few hints relative to that ſcience.

Sounds become pleaſing, not by one continued tone, how loud or ſwelling ſoever, but by their ſucceſſion in agreeable proportion.

Muſicians have contented themſelves with ſeven different notes of ſound, which ſufficiently anſwer all the purpoſes of pleaſure. The differences of ſmaller proportion are ſo imperceptible, that the ear is rather fatigued than pleaſed in making the diſtinction. However, they have admitted half tones; but where muſic is in its infancy, theſe are rejected. The Chineſe have neither flats nor ſharps in their muſic; but the intervals between their notes are in the ſame proportion with ours, as are thoſe of moſt, if not all barbarous nations.

The ancients relate a thouſand ſtrange inſtances of the ef-

fects of muſic. The ſtory of Arion's harp, that gathered dolphins to the ſhip ſide, is well known; and, what is remarkable, Schotteus aſſures us, that he ſaw a ſimilar inſtance of fiſhes being allured by muſic.

However this be, we have many odd accounts of the influence of muſic; and it muſt be admitted that, on particular occaſions, muſical ſounds may have very powerful effects. Horſes and cows in a field will liſten to muſic. Dogs are well known to be very ſenſible of different tones in muſic; and ſometimes ſuſtain very ridiculous parts in a concert, where their aſſiſtance is neither expected nor deſired.

If, as we related, the impreſſions received by ſight are extremely powerful, and ſometimes even fatal, I ſee no reaſon to reject accounts which aſſert an equal power in the ſenſe of hearing; that by this, the ſpirits may be raiſed or depreſſed, may be hurried or ſoothed, and correſpondent ideas not merely tranſmitted, but *impreſſed* on the mind, ſeems very ſuppoſable, and indeed is a well-known fact; that where its powers are augmented by other circumſtances, it may riſe even to rage and phrenſy, may alſo be granted; nevertheleſs, we muſt ſtop ſhort of granting all that has been ſaid in its favour by enthuſiaſts, ſince no modern muſician would venture to encounter a wolf, armed only with his fiddle, nor will harmonious ſounds ſooth the anguiſh of a broken limb, or contribute to ſetting of the bone.

To know the value of hearing, we ſhould conſider its ſervices in the dark, when we are naturally moſt attentive; thus circumſtanced, hearing ſeems to be a warning ſenſe, which,

by giving notice of danger, permits preparation for avoiding it; and, perhaps on this account, ſounds heard at night, are more ſtrongly impreſſive, than when day-light admits completer knowledge of our ſituation, and that of things around us.

But more eſpecially to know the value of hearing, we ſhould reflect, that, without it, how uſeleſs were every endeavour to communicate ſentiments and ideas by diſcourſe, utterly illuſive the pleaſures of ſociety,

"The feaſt of reaſon, and the flow of ſoul,"

the very tenderneſſes of our nature, if conſigned to ſilence: without hearing, vain were every attempt to improve the mind (ſhould we deſire improvement) by ſcience or learning; and vain the attention of the reſpectable aſſembly I have the honour to addreſs.

LECTURE

LECTURE X.

LADIES and GENTLEMEN,

NATURE is replete with evidences of its great Author's beneficence; ſome of them we enjoy, if not completely, yet in very conſiderable and advantageous degrees; and others are either weakened in their properties and effects, or our powers of perception are vitiated, ſo that they little affect us. Man was originally deſtined to inhabit a garden, fragrant as well as verdant, and highly delightful to that ſenſe whoſe office was to judge of odours. But in the preſent ſtate of things, delight is not a conſtant attendant on odours, for ſome are extremely offenſive; nor only have they loſt their property of giving pleaſure, but with their fragrance their innocence; and now, not a few are deleterious and fatal.

I am unwilling to allow that, even in thoſe faculties which belong to the animal part of our compoſition, man is naturally inferior to his fellow creatures; I rather imagine that even in theſe, he was once their ſuperior: and as we have found reaſon to conclude that he ſtill is, in the exerciſe of his touch and his hearing, ſo perhaps he was in that wherein he now ſeems moſt remarkably below them.

Smelling

Smelling.

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Smelling ſeems to have at leaſt as many degrees as thoſe of the other ſenſes; and, like them, it requires repeated exerciſe and conſtant application to perfect it. This may account for its weakneſs in the generality of perſons in civilized ſociety; its primary appointment ſeems to have been that of a kind of *purveyor* to taſting; to judge of what was proper for food, and to determine on the qualities of whatever might offer appearances of edibility; in civilized ſociety therefore, where was no need of ſuch determination, but food was ready ſelected, and only what was nutritive and wholeſome preſented, the ſenſe of ſmelling had no occaſion of diſcriminating, and its judgment being ſuperſeded became gradually weakened, and at length nugatory.

Taſting, in ſimplicity, ſeems to have been attended by ſmelling in perfection; whereas taſting in variety, ſeems to have injured ſmelling by depraving its accuracy. The high ſmells of ſpiceries, and animal food, have by their *piquancy* deſtroyed the ſenſations ariſing from ſimpler nutriment; and in fact, among nations who decline the uſe of animal food, this ſenſe is aſſerted as poſſeſſing powers unknown to us.

The Bramins of India poſſeſs it equal to moſt animals; and can ſmell water, which to us ſeems quite inodorous: we are told alſo, that the negroes of the windward iſlands in the Weſt-Indies, can diſtinguiſh by the ſmell between the footſteps of an European and a negro; and the North-American Indians will (like blood-hounds) trace by their footſteps, the paths taken by their enemies. This, if true, ſeems ſurpriſing,

priſing, ſince the ſcent of a particular tribe among them can hardly be ſuppoſed extremely different from that of any other in the ſame climate, and of nearly the ſame manners, and modes of living. Among the Arabs there have been perſons of ſo acute a ſmell, that when bewildered on the immeaſurable ſandy deſarts of their country, they have been directed in their journey, by taking up a quantity of ſand, and ſmelling to it, thereby diſcovering whether camels paſſed that way; and though the ſame ſand to other perſons might be perfectly ſcentleſs, yet by this, they have aſcertained the cuſtomary path.

Here, if we enquire, whether theſe perſons equally abſtain from animal food? it is anſwered, Not altogether; but, beſide that their fare is ſimpler than ours, it is alſo leſs various, and leſs diſguiſed by its accompaniments. To me there ſeems alſo another circumſtance, not to be forgotten, in this enquiry. It is moſt natural to ſuppoſe perſons who are much in the air (where ſmells abound, and which is their medium) ſhould determine more nicely of its ſtate, and, as it were, its *ingredients*, than thoſe who are conſtantly in their apartments, or at leaſt in their towns (which is the caſe of multitudes in civil ſociety); for in a dwelling, or in a town, whatever care can poſſibly be taken, in reſpect of cleanlineſs, or of ſalubrity, many ſmells of a powerful nature will exiſt; thoſe removed will be progreſſively replaced by others ariſing, and a ſimilarity injurious to this ſenſe will reſult. This may eſcape their obſervation, as Londoners do not perceive the ſulphureous ſmell of their clothes,

clothes, &c. which, on opening a town box in the country, is inſtantly noticed by the country people. The Bramins, the Negroes, the Indians, the Arabs, have no manufactories, nor great towns, nor *aſſemblage* of ſmells, but being conſtantly in the air receive its influences without reſtraint.

It appears from what I have ſaid, that this ſenſe is not ſo important to life as that its abſence ſhould be felt with extraordinary ſeverity, or that vitality ſhould be impeded in its indiſpenſable functions, by the debility of our ſmell. Many perſons are partially, and ſome wholly, deſtitute of it, without material inconvenience; but this could only be in a ſtate of mutual aſſiſtance ariſing from ſociety. Civilization, while it improves ſome, debaſes others of our faculties; by ſubſtituting other pleaſures, other enjoyments, other ideas, than thoſe of ſavage life, by becoming more refined, and more mental, we relinquiſh ſenſual pleaſures (whoſe activity, however extenſive, is limited), for thoſe ariſing from cultivation of our intellectual faculties, whoſe ranges and whoſe acquiſitions, extend beyond the narrow bounds of time and ſpace.

It muſt be owned, that, did we now truſt to the ſenſe of ſmelling as our caterer, we ſhould often be incommoded by falſe intelligence: many things whoſe odour is far from inviting, eſpecially on firſt acquaintance with them, nevertheleſs are both pleaſant to the palate, and wholeſome as nutriment. On the other hand, many ſmells extremely agreeable are highly noxious: we have formerly hinted at ſome of theſe;

and more might eaſily be added. The manchineel apple is not only inviting by its beauty, but by its grateful ſcent; yet this is a poiſon of poiſons. And, if I am not miſtaken, many of thoſe poiſonous preparations in vogue on the Continent a century or two back (and occaſionally uſed in later days), were fragrant, though deadly: the Queen of Navarre was poiſoned by a ſcented powder for her hair; and a Ducheſs of Condé by a plate of perfumed ſweetmeats, preſented to her while viewing a magnificent firework.

Smelling differs in its pleaſures, together with its powers, among different nations, and in different perſons: ſome are enraptured with a roſe, others diſlike it; few I believe enjoy the fragrance of a half-extinguiſhed candle ſnuff, yet a perſon I heard of was delighted with it. The very mention of aſſafœtida is to us diſguſting, but ſavage nations admire it. Certainly habit has great influence on this ſenſe. Many perſons at firſt overcome by the ſmell of muſk, have afterwards carried it about with them. Moſt perfumes which owe their prevalence to faſhion, are inſtances of this; and it often happens, after their faſhionable days are over, much wonder is excited that they ſhould ever have been thought elegant. This is decidedly the caſe with animal perfumes (ſuch as muſk and ſome others); but vegetable fragrance being according to the order of nature, is liable to much leſs variation; that has an invariable relation to us, is a pleaſure conſtant, and often intimate.

Small quantities of perfumes are agreeable, when great quantities of the ſame kinds are offenſive. The ſcent is inſufferable of a large ſtore of ambergriſe; and though a whiff or

two

two of ſmoked tobacco may be pleaſant, a room full, and long continued, is very ſickening to thoſe who are not ſmokers. When ſitting down to table, the ſmell of food is, generally, agreeable; but after having dined, what is leſs tolerable than that of a tavern? This reminds us, that ſmelling quickens the action of the ſtomach, as well as influences the deſire of taſting; and ſeems a deciſive proof, that the ſenſe has a determinate and real relation to the means of ſupporting life.

Smelling has alſo powerful influence on health: I remember reading of a phyſician, who, by way of medicine, daily walked a time in the warehouſes of the India Company at Amſterdam, that he might inhale the fragrance of the ſpices, &c. there depoſited, unpacked, ſorted, &c; and many diſorders of the head, it is well known, are relieved by the ſmelling bottle. But a yet more powerful medicine is ſaid to be, the ſmell of the earth itſelf: I have heard it conſidered as ſovereign for conſumptions, and to this opinion agrees the practice of many a good mother in the country, who makes her child walk in newly turned-up furrows; this contributes to the health of thoſe who drive the plough. As, on the contrary, I have no doubt in affirming, that many of our manufacturers are poiſoned by the ſmells of the employments they follow; as where acids are uſed (as in dying and painting linens, &c.), or metals of various kinds, as houſe-painters colours; not to mention chymical preparations, mixtures, and fermentations.

It is difficult to ſay, how far perſons are influenced by their ſmell in what are termed natural antipathies; whether the ſtrange alarms occaſioned by a cat, or other animal (though concealed),

concealed), may originate from this ſenſe; or whether thoſe who diſlike cheeſe are offended by its ſcent. Of this laſt article, we have a remarkable inſtance in the celebrated Baron HALLER, who, though devoted to knowledge, yet ſuffered cheſts of books to ſtand unviſited, in a diſtant part of his houſe, becauſe they *had* contained German cheeſes. A perſon free from this diſlike, would ſuppoſe the ſubjects of the books little incitive to curioſity, or, this diſaffection acted with a power utterly inconceivable to thoſe free from it.

A ſlight indiſpoſition (as a cold) ſuſpends the exerciſe of ſmelling, and ſometimes changes the effects of odours; ſo that what was before pleaſing now is diſpleaſing, and *vice verſa*.

But if we would wiſh to ſee ſmelling in its higheſt exerciſe, we muſt advert to animals whom it directs in purſuit of prey. As moſt familiar to us, we may inſtance the cat, who diſcovers the haunts of mice by their ſcent; and indeed the ſcent left by theſe little animals, where they frequent, is very diſcernible to ourſelves. We cannot ſay the ſame of the track a fox or a hare has taken in the open fields; we cannot perceive any ſcent, if we examine it directly as they have paſſed; no wonder then if it eſcape us after an interval of time. But we know there are dogs which will trace the ſcent when it is not freſh, will wind, and double, in every track taken by the animal chaſed, and when theſe tracks croſs each other, and are extremely involved, will unravel the whole, and purſue the preciſe path their chace has taken: nor will they be diverted by the track of another animal of the ſame kind, but follow that very individual on which they opened;

only their ſcent is embarraſſed if their chace has croſſed a running ſtream. I ſhould ſuppoſe alſo, a briſk current of air muſt greatly enfeeble their perception; and of this, if I recollect right, beaſts of chace are well aware. The dog in his wild ſtate is very ſagacious of ſcent, and will diſcern carrion (on which he often feeds) at a great diſtance; but, for this, commend me to the vultures, birds appointed purpoſely by nature, as it were, with this deſign; the tainted breeze reaches them from far, and diſtant troops aſſemble to participate the regale it promiſes.

Yet further, may not ſmelling inform certain kinds of birds of paſſage, that at a great diſtance is plenty of the food they love? When the wind has long blown in the ſame direction, may it not impart ſome of the fragrance it derives from paſſing over aromatics of various kinds? That it muſt have loſt much is granted, but that it retains ſome ſeems more than probable, if we recollect, that it occaſionally brings with it the temperature of diſtant climates. At London we have had in February the very air and its mildneſs from Liſbon, as at other times the ſeverity of cold from Iceland; alſo, it is common for ſhips to perceive the fragrance of the ſpice iſlands long before they are viſible, and often, if the wind contribute its aſſiſtance, when they are not within two or three days ſail. If then a ſhip's company, when ſurrounded by ſmells of their own, and heedleſs of thoſe from other quarters, can diſcern theſe juſt mentioned, what ſhould hinder the ſame fragrance affecting more *ſtrongly* at this diſtance (conſequently in a leſs degree at a remoter diſtance), thoſe creatures whoſe organs are

eſpecially

eſpecially adapted to the perfumes of the food they prefer? I do not ſay this will account for the particularities attending the paſſage of birds, but it ſeems the moſt likely manner I can imagine, of accounting for the preſence of certain birds in countries where they were unknown till thoſe countries were cultivated: and not *impoſſibly* it may have a general influence on migratory birds.

I ſhould remark, that heat in general enfeebles ſcents; and few flowers, ſuch as with us are agreeable, beneath the line are in any degree odorous. It ſeems likely alſo, that ſevere cold, by purifying the air, ſhould baniſh ſcent: yet the rein-deer of Lapland dig through the ſnow, preciſely on the ſpot where their *lichen* (their favourite if not only food) grows, directed moſt probably by their acute ſenſe of ſmelling; for no other ſenſe ſeems in any degree relative to the buſineſs.

Some kinds of ſcents extend further than others: ſome are extremely pungent while near, but ſoon diſſipated; others communicate their *haut gout* in every direction, with little loſs. That particular ſtates of the atmoſphere may contribute to this, is very ſuppoſable; but it more probably ariſes from the nature of the odoriferous particles themſelves. We ſmell an odorous body, becauſe it exhales numerous portions or particles of its ſubſtance, which, impregnating the circumambient air, are thereby diffuſed all around. If we take certain fragrant vegetables, we diſcern by a microſcope, little bags of (uſually) whitiſh matter; this is termed their eſſential oil, deprived of which they are ſcentleſs; but this collected ſeparately from the plants, retains its fragrance; and this ſeparation is

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the endeavour of chemiſts, when they wiſh to procure the ſcented oils, &c. of various flowers. This then, is a highly exalted aromatic juice, furniſhed by the plant, of very fine and delicate particles, which, emitted from theſe bags, affect us with the idea of fragrance. But this matter is fragrant not only while in the form of juice, but alſo when dry; yet, as in drying it has given off its moſt volatile particles, thoſe remaining are diminiſhed in number, and alſo in piquancy; hence dried herbs, &c. are inferior to freſh. Spices retain much fragrance, compared to productions of colder climates, becauſe more highly aromatic originally, but compared to themſelves in verdure, their ſcent is feeble. May we not hence ſee why different ſcents travel different diſtances? The particles of ſome may be finer than others, and more may be diffuſed, may float better in the air, as being lighter, or, being more compact in their natures, may be leſs injured (*melted* ſhall I call it?) by its humidity, or other qualities; not to ſay, that ſome being leſs powerful, may require a greater number of particles to effect what others may produce by a few.

This leads us to reflect, that the odoriferous particles of bodies, though ſo extremely fine as to eſcape our ſight, are yet much groſſer than the elementary particles of light, or of air; they have undergone changes whereby they became parts of vegetables, or of animals, therefore are certainly not pure and primitive, but in various degrees compounded and mingled. Shall we ſuggeſt this among the reaſons which contribute to the limitation of the ſenſe of ſmelling? Light, which is ethe-

real, affects us from afar; air in pulsation, if not from so far as light, yet from a considerable distance; whereas odours being but floating particles wafted in the air, are speedily dissipated, and rendered inert. Observe also, that the finer fluids, light and air, need many advantages, and much contrivance, to enable them to produce their effects upon us: they must be strengthened by convergence, and heightened by contrast; whereas the subject of smelling affects us, if not solely by simple contact with the seat of the sense, yet by what is but little removed from it.

It is true, the nostrils are wider at their opening than higher up, yet they have neither the powerful convergence attendant on the eye, nor the curious circumvolutions belonging to the ear; but the upper internal parts of the nose being lined with a nervous expansion, become thereby the seat of smelling. We must, however, remark, that we have the power of strongly inhaling scents, thereby of assembling a greater number of particles, and causing them to act at one time, if not at one place.

The seat of smelling varies in animals; it is prolonged in those of long noses, and the nerves are more convoluted, so that some part or other of them may be affected by scented atoms, which have escaped the parts previously situated. In birds, the orifices which lead to the seat of this sense are very obvious, and usually on the upper part of the bill. In fish no doubt this sense exists, and may contribute many services to those which grope for their food.

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Here let us remark, that probably there is in each tribe of animals a different opinion on the nature of odours. If the vulture were gratified only by what we eſteem grateful, how could he purge the ground from carrion? But while *that* excites him by its ſcent, he freely relinquiſhes what others eſteem. The ſmell of graſs is, no doubt, acceptable to animals that feed on graſs, and that of fiſh, to ſuch as are aquatic. I might obſerve, that the ſmell of fiſh (and that of fleſh, or other things) is itſelf no ill ſmell; but at ſecond hand, as in the fiſhy ſmell of certain birds, is intolerable; and prevents their feathers from being of any value for domeſtic purpoſes.

Smelling has its peculiar advantages, as well as pleaſures: the fragrance of early dawn, of new mown hay, of bloſſoms, of fruit, demonſtrate its pleaſure; and moſt of us can vouch for its utility, eſpecially, when we recollect, that it warns us of the preſence of fire, before it has made any conſiderable progreſs: thus we are enabled to detect and check that devouring element, before it increaſes to a capacity of miſchief. I for one frankly own, that I often truſt to this ſenſe; that I by choice *inſpect* my houſe in the dark, as beſt detective of fire by its light; not without ſcenting cautiouſly whatever ſeems related to the effluvia ariſing from combuſtion. Many fortunate *preventions* have I known, or heard of, for which the parties were indebted to the ſenſe of ſmelling. See then how happy it is for us, that deſtructive element has more than one harbinger, that we have more than one mode of diſcovering it! After this, we muſt eſteem it want of proper reflection, when any one depreciates the ſenſe

of ſmelling: we admit, that it undergoes viciſſitudes, that it is not always to be truſted in caſes of importance; that it is one of the firſt to quit us, and may occaſionally be diſpenſed with; notwithſtanding which, we find reaſon to ſuppoſe, that naturally it has conſiderable accuracy, and would generally direct us in ſafety; that it has peculiar pleaſures and advantages, conſidered in regard of health, or of medicine for reſtoration of health; that it is highly friendly and effectual in its warnings of danger; and if we do not now enjoy it as we might, and as others do, it is no cenſure on the ſenſe, but on what we prefer before it.

We cloſe this diſcourſe by repeating the remark, that the delights of nature would be nugatory, had we not reſpective means of enjoying them, that odours and perfumes, that incenſe and fragrance, were uſeleſs, and their exiſtence without value, did we not poſſeſs the ſenſe of ſmelling: but if among mankind are found ſo many modes of ſatisfaction that ſome may be ſpared, yet let us acknowledge, that among our fellow creatures are many to whom this ſenſe is peculiarly indiſpenſable, who, without it, would linger out exiſtence, and pine in the midſt of plenty. Every thing is beautiful according to the purpoſes to which it is applied, and its aptitude to accompliſh thoſe purpoſes: but when neceſſary to ſupport life, to detect evil, and to ward off misfortune, what is beautiful becomes alſo proportionably valuable and important, a character juſtly attributable to the ſenſe of ſmelling.

LECTURE

Tasting.

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LECTURE XI.

LADIES and GENTLEMEN,

HAVING partly reviewed, in former diſcourſes, the almoſt infinitely varied modes of life and ſenſation, and the ſeveral principles neceſſary to its maintenance and ſupport, we have anticipated much related to the ſubject of TASTING: When we ſaid creatures were endowed with the faculty of digeſting ſuch or ſuch food, and were diſtributed into claſſes according to the kinds of food to which they owed their ſupport, the inference was natural, that their taſte alſo correſponded to theſe diſtinctions, and that the ſenſe was exerciſed in great variety. In recollecting therefore, that ſome creatures feed on living prey and delight in blood, that others prefer prey already dead, that to ſome fruit is moſt reliſhing, to others grain, to others graſs, that fiſh is to ſome the moſt dainty repaſt, while there are thoſe to whom nothing comes amiſs, and who, without reluctance, devour whatever they can conquer: I ſay, when we recollect theſe inſtances, we need not engage in proof that taſte varies. Earth itſelf is thought to furniſh maintenance to ſome creatures, and by its juices to yield them nutriment, while air has the reputation of ſupporting others, and water alſo, others.

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Amid ſo great variety of reliſhes, taſting may be very accurate, yet very different; *that* may be agreeable to one, which is abominable to another, yet the ſenſe be equally exact in each.

The immediate objects of taſting are, ſuch qualities as *ſweet*, *ſour*, *bitter*, &c. and in degrees, but not in extremes, each is pleaſant. But this ſenſe is, after a time, reconciled to what at firſt diſpleaſed it, and after ſuch reconciliation, acquires a fondneſs for what was its averſion. Taſting, therefore, ſeems to be a verſatile faculty, capable of adapting itſelf to contradictory circumſtances. And, among mankind, it is well it is ſo, not only as a variety of gratifications were elſe unnoticed, but as change of aliment is conducive in no ſmall degree to health. This is not ſo to be aſſerted, as if ſudden changes were not extremely prejudicial, yet may fairly ſupport the propriety of that mixture and alternation, which nature offers us in her different productions. While theſe are varied with the ſeaſons, and adapted to their influences, their uſe ſeems to be diſtinctly ſuggeſted; eſpecially, when we recollect, that many of them are tranſitory, that vegetable productions (eſpecially) are but of limited duration, their ſeaſon quickly over, and their perfection ſcarcely attained ere it paſſes. We ſhould obſerve alſo, that *correctors* to the influences of the ſeaſons, are uſually moſt liberally produced by nature in each ſeaſon; herbs of warm properties in winter, cooling fruits in ſummer: and this is much increaſed by the ſkill and induſtry of man, who keeps ſome till they are mellow, and improved from their verdant ſtate; while others he gathers before too much ripe-

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neſs has diſpoſed them to loſe their ſuperior flavour, and more eſtimable qualities.

Should I attempt any thing like an enumeration of what nature offers for human uſe, I ſhould extend this Lecture to great length. Without inſtancing the variety belonging to the fleſh of animals, in taſte and in properties, the vegetable kingdom alone furniſhes multiplied occaſion of remark; for, beſide thoſe changes of aliment which vary with the ſeaſons in temperate climates, there is correſpondent proviſion againſt the intemperance of tropical heats, and of polar colds. Beneath the Line, all manner of cooling fruits abound, and that refrigeration of which the air is deſtitute, is ſupplied by them: witneſs limes, lemons, oranges, &c. of the ſub-acid kind; melons, cucumbers, &c. &c. whoſe degrees of cold would be injurious, if little beyond what they are: two degrees colder, I think, would approach cucumbers to poiſons. The heats of the tropics exalt the flavour of all productions capable of ſuſtaining them; but theſe productions are for the moſt part extremely juicy: firmer kinds, as ſpices, can ſcarcely be called food, though they form a ſmall part of the ingredients in viands. If we advert to the grain of theſe countries, the principal is rice; and rice grows under water, or in ſituations where it has had, during part of its progreſs in growth, plenty of that element. In thoſe hot countries little animal fleſh is uſed, and where health is regarded, little fermented ſpirituous beverages. Simple water for drink, ſimple pulſe or herbs for food, prevail among the natives, who beſt underſtand the *fitneſſes* required by their country.

Temperate climes exhibit the greateſt variety; capable, by the aſſiſtance of art, of adding the richer productions of the Equator to their native ſtores; capable of tranſplanting from diſtant parts, whatever they furniſh worthy attention. In England, we are peculiarly ſenſible of this, if the popular tradition be true, that among apples, only crabs are truly Britiſh, and among plumbs, ſloes. And we ſtill retain the names of countries whence we imported many of our fruits, as currants *(corinths)* from Corinth; damſons *(damaſcuſons)* from Damaſcus; cherries *(cherſoneſes)* from the Cherſoneſe Peninſula; and many others which ſuffer by removal from their native climes, Aſia or Africa, and, lately, America.

It would afford much amuſement to trace the progreſs of a particular taſte, or of a valued fruit, from place to place. Here we ſhould find it admired, becauſe rare, and thought exquiſite, becauſe "we have nothing to compare with it:" there, being plentiful, it would be diſregarded, and becauſe procurable with little labour, thought ſcarce worth that little.

If we trace the progreſs of taſting among mankind, we ſhould find them, at firſt, ſatisfied with the berries yielded by native buſhes, then tranſplanting them into a richer ſoil, and more favourable expoſure, ſtudying to improve their flavour, to embody as it were their juices, to correct their aſtringency, and to increaſe their durability for ſtores; next, importing from foreign parts what they produced of ſuperior value, adapting them to the ſoil and the climate, then grafting and mingling their qualities; ſo that after repeated removals and

unions, they ſhould become naturalized, and invalidate every attempt to determine their original ſtock.

It appears from this ſtatement, that nature has done much for man, but has left him much to do for himſelf; ſhe furniſhes the means which he is to improve, offers the firſt rudiments which he is to complete, not only ſecures him from ſtarving, but, by liberal variety, conſults his appetite, yet never of herſelf produces what is perfect, ſo as to ſuperſede his cultivation, or to pamper his idleneſs. If he wiſhes improvement, it is in his power by induſtry; he ſhall find no ungrateful reluctance to ſecond his endeavours, but his endeavours muſt precede the exertions of powers, which are latent, till he calls them to action. Can there be ſtronger proofs that the original deſtination of man was to attend a garden, to cultivate the earth? whoſe abilities were hid, till excited by a rational being, and varied by thoſe unlimited combinations of which rationality is capable. Nor am I without ſuſpicion, that man has a peculiar genius for gardening; that a ſtrong deſire is by nature implanted in him for its enjoyments, and its productions; that it yields his pureſt pleaſure, united to health and vigour, and is indeed his ſource of genuine delight. Hence thoſe long immured in towns retire to the country; hence rural occupations are ſo agreeable a relaxation; and hence a clear air and extenſive proſpects, or ſilent glades, have no ſmall influence on the ſpirits and the paſſions. Are further arguments neceſſary, to prove that the true taſte of mankind rather relates to productions of the vegetable than of the animal kingdom; and that, however now accuſtomed to the latter, it was

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not ſo in the beginning? Can there be ſtronger proofs, that ſelf-maintenance is all nature impoſes on the individual, other powers of life being provided?

Taſting has certainly greater variety of pleaſures connected with it in man than among animals; they feed on a limited and ſmall number of articles; ſome are reſtricted to a ſingle kind of tree or plant, ſome to a ſingle leaf, others to a particular kind of prey, and theſe perhaps have the moſt ſagacious reliſh. I ſuſpect, that thoſe which devour indiſcriminately, have little or no exerciſe of taſting; and it may be, that the ſenſe of ſmelling is in moſt creatures the more powerful ſenſe: this directs them in the choice of food, and their taſting perhaps could do little more.

DAMPIER tells us in his voyage, that he never ſcrupled to eat fruits, &c. on which he obſerved the marks of birds having been pecking; and he concluded in general, that what was fit for them was wholeſome alſo for man. This general rule has exceptions; as appears in the inſtances of parrots, who ſometimes feed on the manchineel apple. Monſ. BUFFON obſerves, that birds of prey *prefer* thoſe birds of game which man uſually does, and are fond of thoſe of white fleſh, which furniſhes, ſays he, one analogy more between us and them. An adventurous Frenchman, who lately travelled into the interior of Africa, is ſaid to have been accompanied by a dog, a cock, and a monkey. The firſt, as watchful and of approved fidelity, that he might ſleep in ſecurity; the ſecond, as vigilant, that he might riſe at day-break; the third, that he might aſcertain whether the fruits he found were edible; concluding, that if

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the monkey ate them, he might ſafely follow his example, but if he rejected them they were pernicious. The analogy between the monkey tribes and man in ſhape, &c. ſeems to indicate, that what was good for one could hardly be hurtful to the other; and in point of inſtinct, the advantage is with pug, as no doubt it is with animals in general. Even a hog, though eſteemed a voracious glutton, has too much taſte to eat indiſcriminately all the plants offered him; but, I think, out of 250 rejects 100. This choice belongs to moſt, if not all graſs-eaters; for as nature exhibits the utmoſt variety among vegetables, did all animals chooſe alike, thoſe remaining would multiply to exceſs. The ſame may be ſaid of aquatic birds, which, among the numerous tribes of fiſh, have doubtleſs their favourites; and of quadrupeds, which, though they feed on many kinds, are peculiarly fond of ſome: as we ſee dogs, if not ſeverely preſſed by hunger, ſeldom eat rats; and cats prefer the mouſe, though they feed on other creatures. Animals, like ourſelves, may be depraved in their taſte; we have heard of a horſe that ate oyſters; and of Diomed, king of Thrace, who fed his horſes on fleſh, and was at laſt devoured by them; a fate he well merited! Savage beaſts alſo eat others of their own ſpecies, as wolves, jackalls, &c.; and among depraved or impetuous taſte, perhaps we may include the ſtrange diſpoſition of ſome creatures to eat their own young. As to depraved taſte in the inſtances of green-ſickneſs, &c. that is diſorder of more than the mere ſeat of the ſenſe.

Taſting is not always determinative of the ſalubrity, or inſalubrity, of food: much that is ſweet is hurtful; but in general,

neral, what is offenſive to the taſte is with propriety rejected. We cannot *abſolutely* truſt to our ſmell, or our taſte, when they pronounce in favour of what they examine, but what they diſlike is uſually worthleſs, if not dangerous.

We ſaid, the ſenſe of ſmelling had ſuſtained in man great injury, by artificial ſcents and provocatives; artifice has had at leaſt equally injurious effects on taſting. Epicuriſm has depraved the ſenſe, and thoſe who cannot reliſh a meal without ingredients of high flavour, and of contradictory poignancy, not only injure their health by embarraſſing the operations of nature to promote it, but muſt be conſidered as perſons of the moſt depraved appetites; as fartheſt departed from the ſtandard of what is beneficial, and as indulging a tranſitory gratification, at the expence of permanent ſatisfaction. Health is the chief end of nature, when the ſenſes of ſmelling and taſting are in their full powers: the ſmell excites the taſte to enjoyment, or prepares it for diſguſt; and diſguſt keeps clear of what might prove prejudicial to the functions of life. But, if taſte be excited by ſmell, there is yet a chance that when itſelf is engaged in judging, it may rectify the errors of the former; as well as determine on ſubjects, whoſe ſcents are neither attractive nor repulſive.

The immediate ſeat of taſting is the palate: the tongue ſeems to partake of the ſenſe, but not in all caſes. The tip of the tongue dipped into ſugar, will not communicate the idea of ſweet till it has touched the palate. Yet by ſome ſubſtances the tongue is affected; hellebore affects the inner part of the tongue, mezerion the throat, and peppermint drops laid till they

they diſſolve on the tongue, may be taſted. It ſeems, indeed, that moiſture is neceſſary to taſting; and muſt either be furniſhed by the ſubject to be taſted, or by the *ſaliva*. For when both the ſubject and the tongue are dry, no taſte whatever enſues. A mere ſenſation of feeling is all which takes place.

Taſting, like our other ſenſes, is performed by nerves, ſpread to receive impreſſions: theſe are diſtributed over the tongue and palate, and fill the *villi* (little riſing proceſſes) of thoſe parts. Theſe *villi* are varied; and (probably) among creatures poſſeſs different powers, ſo that what to one kind ſeems pleaſant, to others is diſagreeable. Some perſons have endeavoured to account for taſte, by conſidering it merely as a nicer kind of touch: pointed bodies, ſay they, applied to theſe *villi*, excite a powerful ſenſation,—theſe are ſalt: other bodies being rounder, ſlide ſmoothly along the *villi*,—theſe are ſweet. Theſe principles may be true, or they may be erroneous.

Taſting varies with the progreſs of life; children abounding in moiſture, taſte every thing much ſooner, and though its reliſh be feeble, than grown perſons; to which effect, no doubt, contributes the yet comparative purity of their organs, not vitiated by the perplexing variety, or the piquant ſtrength, of what they have been accuſtomed to. Age, on the contrary, is not without difficulty excited to the enjoyments of taſting, eſpecially where intemperance has injured the organs.

Thus have we noticed the principles of the ſenſe of taſting: obſerving, that it differs in its choice among animals, and determines them to the nature of their food; that its verſatility

accommodates itſelf to what was once its averſion; that nature has amply provided for gratifying its variety, and directing it to beneficial effects; that it excites human induſtry, and ſeems deſigned for that purpoſe. We have obſerved alſo, the ſeat of this ſenſe, its powers, and the changes it ſuffers by cuſtom, and by the courſe of years. We remark on the whole, that to preſcribe rules for its direction is impoſſible: what is pleaſing to one offends another, and the liberty of private judgment is here at leaſt inviolable. It alſo reſults, that as taſting was intended as a guide to healthy nutriment, every depravation of it is attended with danger, every intemperance is not only a riſque for the time, but for futurity; leſt it ſhould riſe into habit, and, if confirmed, be extremely detrimental. The great leſſon taught by nature, is MODERATION: all beyond tends to enfeebled powers, to enervated imbecility: *ſo much* is fit and proper, *ſo much* may be pleaſant, *ſo much* may be endured. Nature revolts if further provoked, and puniſhes by depravity and deprivation, thoſe who ſtimulate her powers to exceſs.

LADIES and GENTLEMEN,

WE have now diſcuſſed thoſe principles, which we eſteem ourſelves juſtified in conſidering as indiſpenſable to life: abſtract any one of them, we ſenſibly feel its abſence, though not equally the abſence of each. What now remains is, to relate ſo much of the manners of creatures, as may ſupport what has been aſſerted, and may enable us to underſtand that variety, that unlimited variety, with which nature abounds.

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It is not to be ſuppoſed, that, in offering *general principles*, we ſhould be able to include *every particular*; after all poſſible care, much that is intricate will elude our diſtinctions, much that is novel will apparently controvert received opinions, much that is rare and extraordinary will perplex our judgments, though formed on the ſoundeſt principles, and ſupported by analogy of numerous and well-authenticated facts.—In the celeſtial expanſe of ſtars, obſervation has diſcovered many, and endeavoured their arrangement; the *chief* may be arranged; theſe form the ſigns of the Zodiac, or compoſe the conſtellations of the heavens; but after much ingenuity, and great variety of figures, many remain *unformed*; many are too ſmall to be included, many are but lately known, as inſtruments became perfected, and where formerly we reckoned three thouſand, now (by Mr. HERSCHELL) is reckoned *thirty thouſand:* Such is the ſtate of general principles when referring to the extent of nature's works. But as theſe new ſtars are, either *in*, or *near*, adopted conſtellations, and may be conſidered as allied to them, ſo whatever among the tribes of nature is ſingular and wonderful, rare and perplexing, as our knowledge increaſes may be referred to ſome or other of thoſe principles which have engaged us. For, many things are wonderful, only becauſe we ſee them but *partially*; when their whole connections are known, the wonder ceaſes: As we admire thoſe inſtruments whoſe powers are hidden, but when acquainted with all their machinery, our ſurpriſe, at leaſt, is moderated. Nay, with regard to moſt con-

ſtructions

ſtructions of human art, familiarity with them leſſens our eſteem or applauſe:—becauſe we perceive their limits, and diſcover their imperfections, we find many aukwardneſſes, and much that is miſplaced. This conſtitutes a ſtriking difference between the productions of creatures like ourſelves, and thoſe of Omniſcient Wiſdom;—which ever excite freſh admiration, as we become more intimate with them, and open thouſands of excellencies, to the diſcernment of thoſe who, by attentive diligence, have acquired a worthineſs of ſuch diſcoveries.

We cannot direct one cauſe to many effects, like nature; nor foreſee as well benefits as inconveniencies, at a remote diſtance; we cannot force ſeeming evils to advance ſubſtantial good, make deſtruction the parent of population, make barrenneſs contribute to plenty, and revive disfigured beauties with heightened delight; we cannot unite the ſnow-topp'd ſummit and volcanic entrails, in the ſame mountain, thereby engaging heights and ſpots precluded from general uſe to promote general advantage; we cannot direct the exhalations of mines, and their deleterious effluvia, ſpreading deſolation around their ſeats, to produce the means of fertility; we cannot rule the heaving earth, and regulate its convulſive ſtruggles;—If unable to controul inanimate matter; how ſhould we comprehend the ſprings of vitality, or trace to their origin its various modes? How ſhould we determine its degrees,—its maintenance—and ſupport? The ſcale of life embarraſſes our conceptions, the diſtributions of life our judgments, the members of life, their actions, their offices, their principles, perplex us, even in their lower ſtages, as

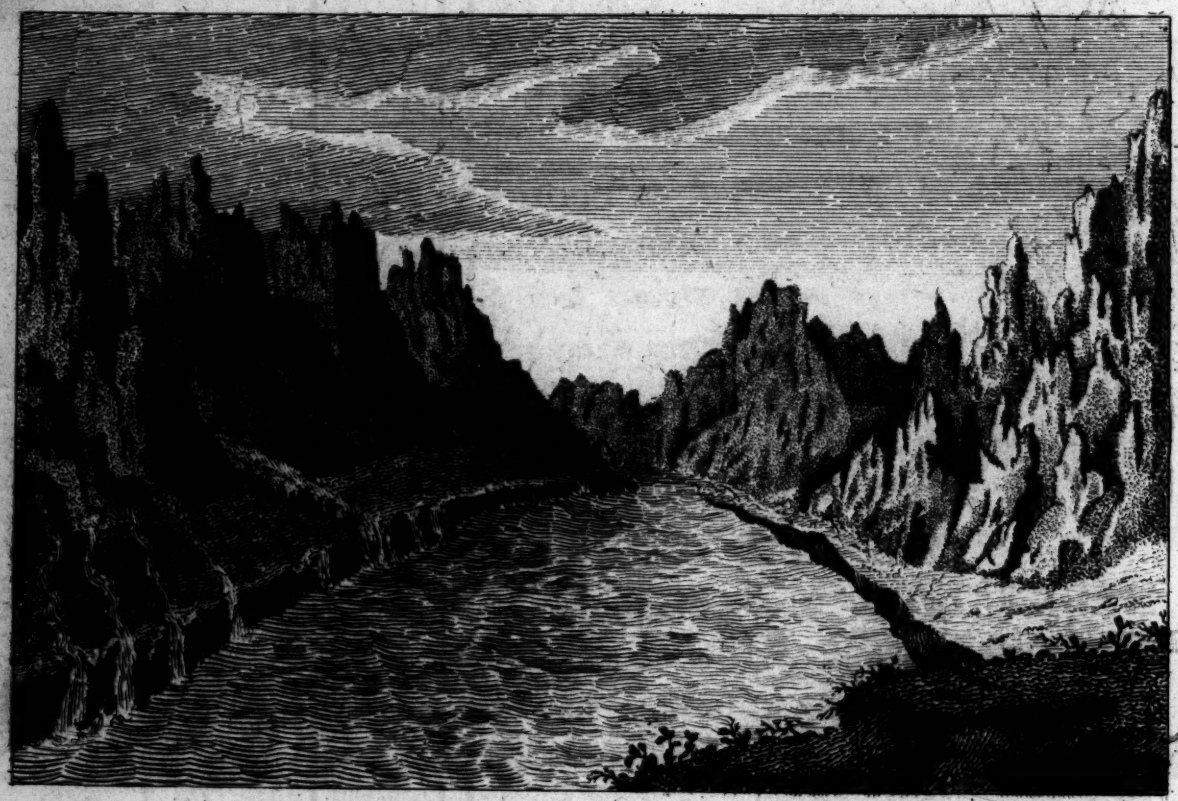
exhibited

exhibited among creatures our inferiors. And if we advert to ourſelves, inveſtigate rationality, and conſider properties and effects attendant on reaſon, we are bewildered and confuſed, we heſitate and faulter, we hint, we imagine, we ſuppoſe, we gueſs, but determine nothing: arguments lead where we fear to follow; and we yet may appropriate the precept, "know thyſelf."——But we trace, if not principles, yet their action; if we cannot demonſtrate the ſenſorium, we are certain of the ſenſes; and however we may be ignorant of their tranſmitted effects, their exerciſe is perſonally evident. Surely we feel, and ſee, and hear, and ſmell, and taſte: we cannot, while in our ſenſes, queſtion their natures. We know alſo, our ſenſes act by the nerves; that if theſe be abſent, or injured, if weakened or embarraſſed, if too tight or too lax, ſenſation ſuffers. If we perceive not how theſe nerves affect the brain, or are themſelves affected, at leaſt we diſcover wonderful contrivance, in their appointments, their ſituations, their combinations, their preciſe fitneſs for the offices wherein they are engaged, their happy arrangements, and appropriate peculiarities. In poſſeſſing ſuch variety, we notice our favoured ſituation above creatures deſtitute of ſeveral, and we infer, that as they are incompetent to our ſhare of knowledge, ſuperior beings may poſſeſs additional means of information; circumſtances that eſcape us may be to them familiar, circumſtances that perplex us, may lie open to their inſpection; they may eaſily unravel intricacies which bewilder our reaſonings, and embarraſs our conjectures. Are then creatures below us leſs happy, creatures above us more happy, than ourſelves? No:

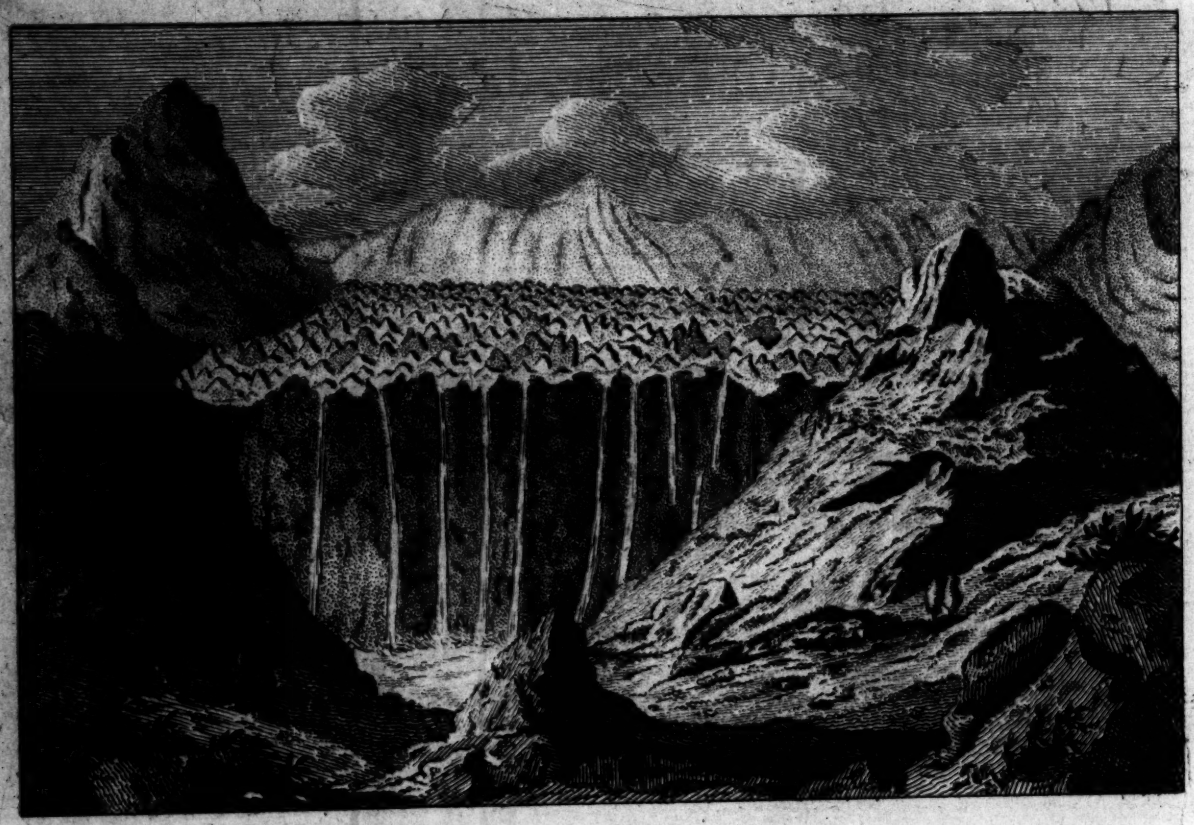
happineſs ariſes from filling up with propriety that ſtation in which we are placed by Divine Providence, whether exalted or abaſed, whether ſplendid or obſcure, whether of example or of imitation, *that* ſtation is appointed us by Infinite Wiſdom, who never determines raſhly on ſtations or their occupiers. Should the ear refuſe its office, becauſe not privileged in point of diſtance like the eye; ſhould the palate refuſe to taſte, or the noſe to ſmell, becauſe reſtricted to determinate parts, not general over the perſon, what confuſion would enſue! Should we repine at our portion of ſenſes, becauſe creatures our inferiors enjoy greater degrees, what unthankfulneſs would it indicate! To neglect what we have, out of envy at what we have not, were at once ingratitude and folly.

O for a grateful heart, ſenſible of the obligations ariſing from conſtant reception of benefits, from conſtant vigilance for our welfare, and conſtant attention to our intereſts, in that great Being, who, if diſtance might include neglect, never need think of us, never need direct to us one complacent ſmile, one beam of mercy! Yet notwithſtanding diſtance and unworthineſs, negligence and inattention, who daily becomes our benefactor, and "in whom we live, and move, and have our being."

OBSER-



GLACIER in SAVOY.



GLACIER in the Canton of BERNE.

OBSERVATIONS ON THE PLATES,

BELONGING TO THE

SECOND SERIES OF LECTURES.

GLACIERES, TWO PLATES.

GLACIER IN SAVOY.—Shews the vaſt bulk of the ſnow mountains; which, after having accumulated beyond the power of the ſun to thaw above, are melted by the heat of the earth below, and form thoſe torrents to which rivers owe their birth.

GLACIER IN THE CANTON OF BERNE.—Shews a ſnow valley of amazing height, ſurrounded by mountains of ſnow, which, reflecting the ſolar beams, gradually warm the valley, where alſo, being agitated, they melt the ſuperficies of ſnow, and cauſe it to run down the ſides of the Glacier in numerous rivulets; ſome of which, when the ſun ſhines on them, ſhew rainbows, and other curious meteors.

From the union of theſe cauſes, appears, why the Glacieres in general increaſe now but little, if at all; ſo much of their ſnow being melted by the ſun, or undermined by the heat of the earth. Theſe are the origin of the greateſt rivers of Europe, the Rhine, the Danube, the Rhone, &c.

THE EYE.

No. I. Is explanatory of the ſeveral refractions of the rays of light, in order to their acquiring a true and exact focus.

The outer coat of the eye is termed the *ſclerotica*; adjoining is the *choroides*, which is lined by the *retina*. B *c d* B, is the tranſparent part of the ſclerotica called the *cornea*; between which and C C (the *cryſtalline humour*) is placed the *aqueous humour*. D D the *vitreous humour*, occupying the remaining internal ſpace of the eye. N the *optic nerve*, inſerted laterally, leading to the brain. *o o* the pupil.

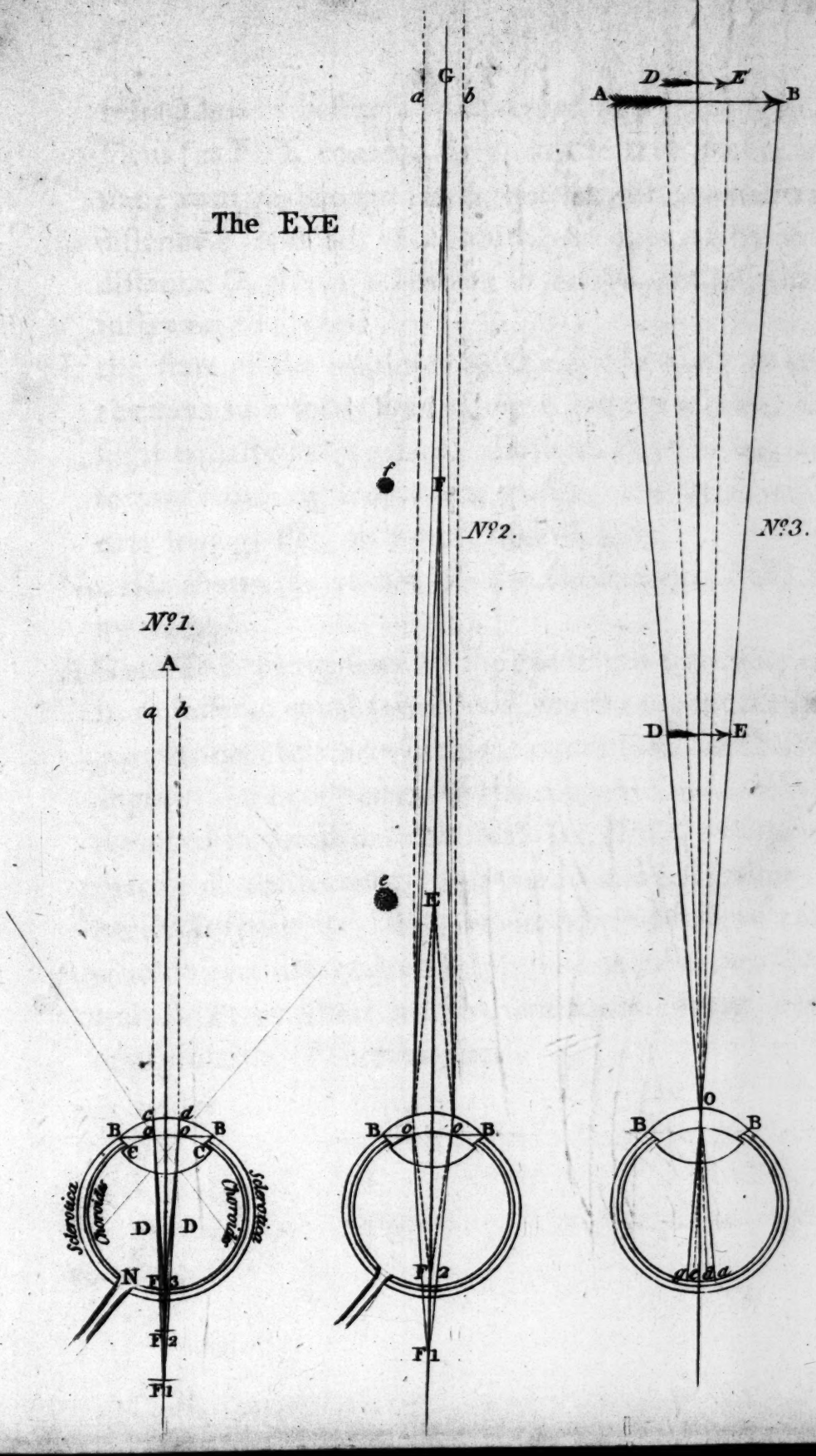
A is a ray which, ſtriking the eye preciſely centrally, needs no refraction in its paſſage to the bottom of the eye.

a b, are two parallel rays, ſtriking the eye in *c d* (the cornea), whoſe refractive powers would divert them from their direct courſe, to a focus beyond the extent of the eye (as F 1,) were no other medium interpoſed: but, in their paſſage to F 1, they impinge on (C C) the cryſtalline humour, and by this are again converged to a nearer focus (F 2): But as this alſo is beyond the limits of the organ, they are, in paſſing out of C C into the vitreous humour, again converged, and fall exactly on the nervous expanſion of the retina, at a third focus (F 3), there producing perfect viſion.

No. II. ſhews the imperfection attending viſion, when the focus is formed *behind* or *before* the retina.

If an object (E) be too near the eye when viewed, the rays proceeding from it will, after entering *o o*, and ſuffering the refractions

The EYE


Nº1.
A
a b
B B
c d
C C
Sclerotica
Choroides
Choroides
Sclerotica
D D
N
F3
F2
F1
Nº2.
G
a b
f
F
e
E
B B
c d
F2
F1
Nº3.
A
D E
B
D E
O
B B
a a a

refractions as before, be converged to a point *beyond* the true focus (as F 1), conſequently, *at* the true focus, may depict ſome confuſed image (as *e*), but on juſt repreſentation. The diſtance F is nearer the truth, as appears by *f*. At the diſtance G, the rays become ſo nearly parallel, that they fall juſtly on the retina.

If the ſtate of the humours in the eye be ſuch as to converge the rays to a focus *before* they reach the retina, dimneſs of ſight equally takes place. Both theſe diſorders occur; the former requiring *convex* lens glaſſes, the latter requiring *concave* lens glaſſes, to correct their defects.

No. III. ſhews the reaſon of the diminution of objects in ſize, by diſtance.

A G and D E being ſeen by the eye in the ſame line, after they have ſuffered equal refractions, depict on the retina the object *g a*; or occupy correſpondent equal ſpace on the retina; the angle *g* O *a* being equal to the angle A O G. Whereas D E, removed to the diſtance of A G (as *D E)*, occupies only the ſpace *e d*, conſequently appears ſo much ſmaller to the eye which inſpects it. But (while otherwiſe ignorant) the eye would never determine the proportionate dimenſions of D E and A G; or their relative diſtances, being deceived by the ſimilarity of their angles.

THE

THE EAR.

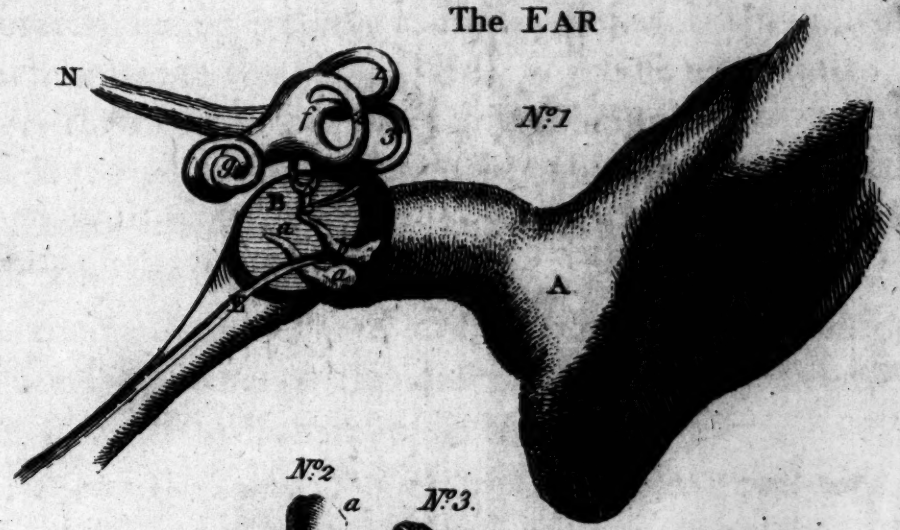
The conſtruction of the parts adapted to hearing, is ſo complex and intricate, that it is extremely difficult to convey juſt ideas of their ſituations and uſes, either by deſcription or repreſentation; we have therefore enlarged the parts ſeparately, as well as ſhewn them united.

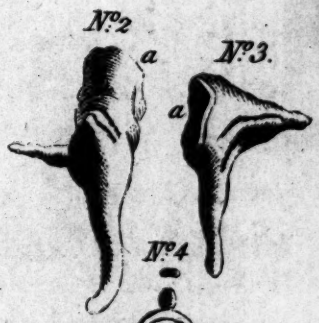
No. I. A, the external auditory paſſage (whoſe commencement at the ear is too well known to need explanation), tracing which, *internally*, we come to B (the *membrana tympani*, or drum of the ear) which is an expanſion almoſt circular, tightened or relaxed, by *a a* (the *malleus* or hammer), which reſts on it, about its middle. The malleus is at its head articulated to *b* (the *incus* or anvil), which, at its other part, joins a very ſmall bone the *orbicularis*, and this the *ſtapes* or ſtirrup *c*, whoſe office is to cloſe, by its other end, the orifice of the *foramen ovale* in the *veſtibulum*. *f* is the veſtibulum, *g* the *cochlea*; 1, 2, 3, the ſemicircular canals; N the auditory nerve, entering the veſtibulum, and lining it throughout; E the Euſtachian tube, which communicates with the mouth.

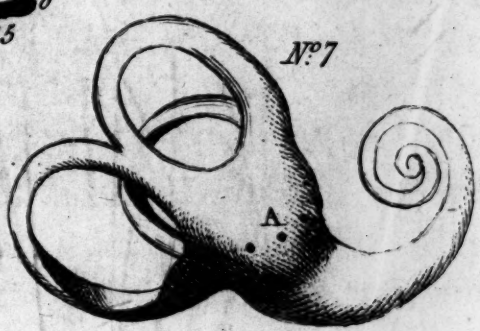
It ſhould be remembered, that theſe parts are ſurrounded on all ſides by the bone of the ſkull, conſequently are hollowed out of it; but that covering being ſuppoſed abſent in this repreſentation, no regard can be had to the *bearings* of theſe parts in relation to it.

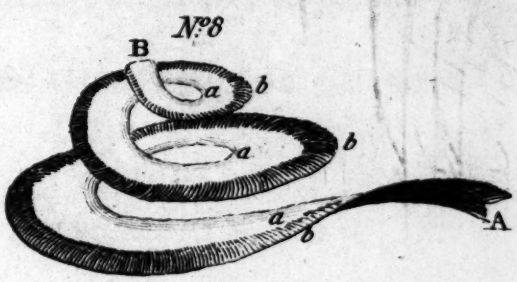
No 2, is the bone *malleus* at large, ſhewing many *riſings*, &c. whereby it is held more ſecurely in its place. *a*, its head,

The EAR









which articulates into the hollow, *a*, of No. 3 (the incus), accurately fitting its irregularities. No. 4. is the orbicularis, which unites to the ſtapes, No. 5, whoſe termination, *a b*, covers the foramen ovale of the veſtibulum.

No. 6. is the veſtibulum at large; ſeen on that ſide which ſhews the *feneſtra rotunda* (*a*), and the *foramen ovale* (*b*); which laſt is ſhut by the ſtapes.

No. 7. the veſtibulum, ſeen on that ſide which ſhews the perforations, A, whereat the auditory nerve enters the veſtibulum, in order to line its inſide *throughout*.

No. 8. ſhews the ſpiral diviſion of the *cochlea*: part appearing bony, part membranaceous and nervous in texture, whoſe cords lie in the direction expreſſed by the ſtrokes; theſe varying in length ſo greatly, and with ſuch regularity, are adapted to receive impreſſions of all degrees or tones of ſound.

The courſe of ſound is, from its entering the ear to the membrana tympani, [but if the ſound enters through the mouth (as that of a watch held between the teeth), then it is through the Euſtachian tube] into the cavity of the drum; where, exciting the ſmall bones there ſituated, it is tranſmitted into the veſtibulum, which is the immediate ſeat of hearing, partly through the feneſtra rotunda, partly through the foramen ovale, if the ſtapes be pulled away from it.

End of the SECOND SERIES *of* LECTURES.